ELECTRICAL
AND
ANATOMICAL
DEMONSTRATIONS.

DR. TIBBITS.

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ELECTRICAL AND ANATOMICAL DEMONSTRATIONS

ELECTRICAL AND ANATOMICAL DEMONSTRATIONS

DELIVERED AT

THE SCHOOL OF MASSAGE AND ELECTRICITY

IN CONNECTION WITH THE WEST-END HOSPITAL FOR DISEASES
OF THE NERVOUS SYSTEM, PARALYSIS AND EPILEPSY
WELBECK STREET, LONDON

BY

HERBERT TIBBITS, M.D.
FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, EDINBURGH
SENIOR PHYSICIAN TO THE HOSPITAL, ETC.

A Handbook for Trained Nurses and Masseuses

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LONDON
J. & A. CHURCHILL
11 NEW BURLINGTON STREET
1887

PREFATORY NOTE.

THESE Demonstrations are printed as a Textbook for the Students of our School of Electricity and Massage, and for Hospital Sisters and Trained Nurses in general.

The Author considers that the time has fully come when such instruction is imperatively called for, and he has reason to believe that other Physicians who practise chiefly in Diseases of the Nervous System are in agreement with him.

Students who, *without assistance,* endeavour to master the anatomical details are advised to get a piece of tracing-paper, to copy Figures 10 to 41, and to gum them upon a sheet of white card or millboard, about twenty-two by fourteen inches, and to use the map so made for *constant reference* to explain the text.* The whole matter will not cost more than a few pence, and the memory will be materially assisted. They should also study each anatomical figure through a good magnifying glass *again and again*, and try to recognize all the muscles, nerves, &c., mentioned in the text.

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* Messrs. Churchill have also reprinted the Anatomical Figures without the text: thirty figures in 8vo, cloth, price 1*s.* 6*d.*

Of course no endeavour is made to do more than point out the "landmarks" of Electrical Anatomy and Physiology; but it is believed that the knowledge—as far as it goes—is thoroughly scientific. The anatomical woodcuts, which Messrs. Churchill have courteously supplied, are as perfect as such things can be, and are reproductions from some of their well-known Manuals, chiefly from the writings of the late President of the College of Surgeons, Sir Erasmus Wilson.

One decided novelty has been attempted. The Student is credited with possessing *some* sense, and with being able to recognize for himself or herself the objects delineated in the engravings without endless reference to "*a*, *b*, *c*," or "1, 2, 3," &c.

It has been thought better not to alter the familiar and colloquial style in which the Demonstrations were given; and they are printed as spoken.

The book is intended as a companion to the Lectures on Massage recently published by the Author's colleague, Dr. Stretch Dowse; and it is hoped that it may prove not only useful to Students at the School, but serve also to direct public attention to a new and altogether suitable vocation for well-nurtured and educated women.

H. T.

68 Wimpole Street, London, W.
March 1887.

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ELECTRICAL AND ANATOMICAL DEMONSTRATIONS.

DEMONSTRATION I.

In giving my first lecture and demonstration at our School, I propose to follow what seems to be the prevalent custom upon such occasions—to ask your indulgence while I make one or two introductory remarks. We offer no apology for the foundation of our School, nor do we rest satisfied by merely pleading, as a justification that duty incumbent upon every member of our profession, especially those who enjoy the privilege of hospital practice—the duty of communicating to others the knowledge gained from our patients : a duty which, it has been well said, " continues to the end of our lives, and which can no more be thrown off than can the obligation of a crown or of inherited wealth." In addition to this plea, we say that we could not, with due regard to our Hospital and to those associated with it, continue to go on as heretofore, hiding our light under a bushel, and content solely in our quiet work of healing the palsied and the lame. The treatment by Massage and Electricity—a treatment that we have assiduously studied and developed daily for many years, both here and elsewhere (and we have had more than 60,000 attendances here)—is now being placarded as a novel remedy! Ladies of title write about it in popular journals, and people cry out, "Behold! Here is some new thing under the sun!" Surely, then, we could not longer remain silent, and allow our clothes to be stolen from us and worn by others; and I am proud that our Hospital has been the first hospital in this great metropolis—nay, in this great country—that has had the foresight and wisdom to open out so promising a career for those whose lot in life it is (as is the case with most of us) to work before we can eat; for I know no better, no more useful, no more honourable, and no more fairly remunerative calling for any one with some aptitude and some love for nursing (*and this is essential*), than that of a Masseuse or Electrician.

It was recently set forth in the leading medical paper that Massage and Medical Electricity should never be administered to patients by any others than legally qualified medical men. If the paper in question had contented itself by saying that these methods of treatment should only be administered when prescribed by medical men, and under their supervision—*and even then only by nurses thoroughly trained and experienced in such applications*—I should have been in entire agreement with it; but the journalistic statement as quoted seems to me to have no justfication.

A physician wrote to me the other day, that "the great difficulty he found with regard to Medical Electricity was, that he could not afford the time to apply it himself: that when applied by others there was no certainty that his directions would be carried out correctly; and that the result under such circumstances had been so often unsatisfactory that he had given up prescribing it."

I submit that such a letter as this goes far to prove that our School has been founded none too early; but in support of this opinion I will give you two cases.

A paralyzed child was brought here. It had been submitted to the torture of a magneto-electric machine—a thing with no means of graduating its power, extremely painful in application, and which never ought to be used at all—for twenty minutes five or six times daily for months. The child screamed at the sight of the instrument, and the mother said: "Yes, it always *did* scream; but the doctor said it was the only chance of cure, and it must be done." It will be a mercy if this poor child's nervous system proves *not* to have been irretrievably damaged by such a cruel and utterly unjustifiable proceeding. The machine is shown in Fig. 1, which also illustrates in another respect "How not to do it!"

You will observe that the conductors are grasped one in each hand. This sort of thing can be seen any day upon race-courses; always, I think, on the pier at Brighton. As regards any benefit, you might as well affix one conductor to the knocker of the house door and the other to the bell-pull, which could do no harm; but applied to a patient, the proceeding is not free from danger.

A case has been reported, in which a man, suffering from apoplexy, took the conductors in his hands, *and was unable to let them go*. The instrument he used was worked chemically; no one else was in the room, and when after a time some one came in, the unfortunate man was found lying in convulsions upon the floor, stricken by another apopleetic seizure.*

Not a single week passes without patients coming to this Hospital, and reporting that they have been instructed by their doctors to galvanize either themselves or their relatives in the way delineated in Fig. 1.

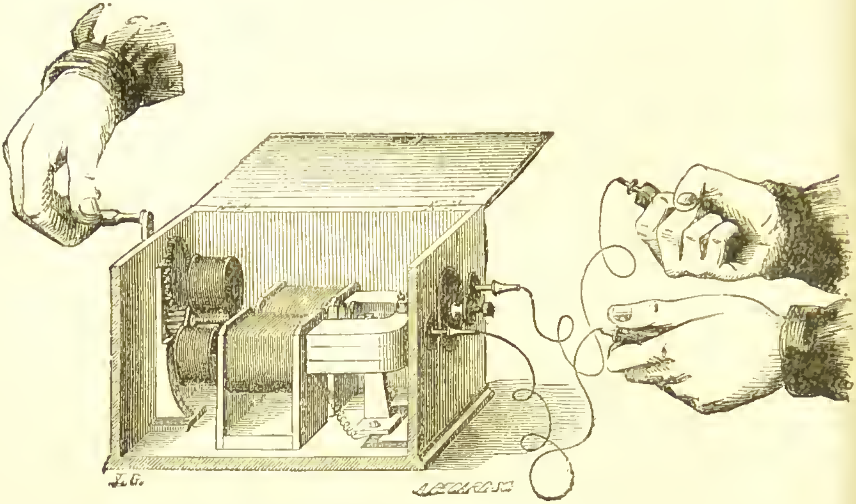

Fig. 1.—The worst Machine, and the worst way of using it.

Yet one other case. A surgeon brought me a little girl eight years old, whom he told me he had galvanized nearly every day for some three months. He brought the battery with him, and we proceeded to galvanize the child with it. She was a bright intelligent little woman; and she said "she was much better, and that she liked it."

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* See Duchenne (De Boulogne) "On Localized Electrization and its applications to Pathology and Therapeutics" (English Edition), p. 125. London: Churchill.

I asked my friend to test the strength of the electricity upon his own face. His reply was: "Thank you; I would rather not." And, by the way, it is remarkable how ready some men are to apply painful electrization to their patients, and how exceedingly careful they are not to feel any of it themselves.

To cut the story short: we found that a connecting wire in the battery was broken; that no electricity reached the patient; and that the solemn farce of a solemn-looking doctor armed with a couple of wet sponges had been going on for months. But the little girl said she "was better." Although the *Vis Medicatrix Naturæ* is great, I could not but be reminded of the recent cartoon in *Punch*, of the street Arab lying in bed and having his temperature taken by a thermometer, and saying to the doctor who was taking it: "Ah! sir, that's doing me a power of good, that is!"

Now, with reference to such cases as I have just quoted, men cannot be expected to understand what they have never been taught, and the responsibility for any want of necessary knowledge in medical practitioners rests upon their Medical School. Some fourteen or fifteen years ago, one of the largest Medical Schools in London sought my advice as to the best electrical apparatus for hospital use; I advised them to the best of my ability, but the matter was adjourned for several years, as the authorities would not expend more than £10!

It has recently been stated that "it takes at least two years to learn the art of massage, and that the masseuse *must* be an educated lady." With the first part of this statement I entirely disagree: if a student, man or woman, cannot become proficient in the application of both massage and electricity with six months' tuition and practice, he or she never will. With the second part I am in cordial agreement, and to the word "masseuse" I would add the words "or nurse-electrician." But we shall have to ask several questions during these demonstrations which will be easier to answer than the one I now put to you. What *is* an educated lady? I will not myself attempt an answer, but I will give you two quotations; one is from a certain play-writer, William Shakespeare by name, and it assuredly applies to those who nurse the sick—"*Sweet mercy is nobility's true badge;*" the other is by Sir Walter Scott: you all know it, but it will bear repeating:

> "Woman, in our hours of ease,
> Uncertain, coy, and hard to please;
> When pain and anguish wring the brow,
> Woman, a ministering angel thou."

I would substitute for the word "lady" the word "gentlewoman." On reference to my dictionary, I find that this latter word exactly describes the perfect masseuse or electrician: "a woman bland, mild, meek, soothing, peaceable, not rough or severe." *A gentle woman who* NEVER *applies electricity to a patient without first applying it to herself.*

Should I ever personally require the aid of a masseuse, my hope is that I may secure such an one.

In this present course of demonstrations I shall consider, firstly, so much of the science of electricity as is essential to medical practice, and then the construction of batteries and the way to keep them in order.

As electricity cannot be applied to a patient intelligently and profitably by "rule of thumb," you *must* possess a competent knowledge of the osseous, muscular, and nervous systems, and so much as it is imperatively necessary to know I shall endeavour to teach to you, the non-medical part of my audience, and I feel sure that my medical friends who are present will bear with me while I enter upon anatomical details with which they are familiar, and which I fear will take up quite half of my next lecture. After these details are disposed of, I shall consider the way to use electricity; and afterwards the diseases which always require electrical treatment, and those which only occasionally do so; and I shall conclude the course by recapitulating the more important points, and by grouping together such scraps of information about electrical matters as are calculated to help you, but which could not be conveniently considered under any special division of our subject.

I shall explain the methods of applying electricity by actual demonstrations on patients; and after I have done so, I propose that, under my immediate supervision you shall each of you make the same applications which you will have seen me make, for theory is one thing and practice altogether another. Let us hope that we shall succeed in so combining the two that you will find that your attendance here will have been in every way time well and profitably spent, for by becoming qualified in electricity as well as in massage (and the two are almost always employed in conjunction or alternately), you will occupy a distinctly better position than those having knowledge only of one of these methods of treatment.

What *is* electricity? This is a question much more easily asked than answered. Faraday, undoubtedly the most profound electrician the world has ever seen, and who devoted a long life to its study, said that "he once thought he knew something about it, but he found that the more he investigated it the less he understood it." It is one of what—for want of a better name—we call the "physical forces." It is supposed that there are two different kinds of electricity, equal quantities of which neutralize each other, and that every substance in Nature—you and I included—contains these two kinds in equal quantities. By "*different* kinds" it is not meant that there is any *essential* difference between the two, for there is not, *but merely that they combine with and neutralize one another.* By suitable methods of procedure we can bring about their forcible separation, and render each kind manifest. When they are separated, the one kind is called "positive," the other "*negative*" electricity; but they will try very hard to unite again, and you will have great difficulty in preventing them. They have, each of them, the strongest inclination to diffuse themselves over any substance brought into contact with them in search of one another, for remember their separation was a forcible separation. We have heard of the loves of trees and plants: does this feeling extend to positive and negative electricity? for their desire to meet is so strong that they will travel along a copper wire towards each other at the rate of two hundred and eighty thousand miles a second (quicker than light travels); and hence has been deduced the first great electrical law: "Like electricities repel each other, unlike electricities attract each other;" that is, positive repels positive and attracts negative; and similarly, negative repels negative and attracts positive. This accommodating copper wire is therefore, and I think very properly, called a "conductor." Need I tell you that, as a matter of course, there are substances which will do all they can to prevent this reunion? Such substances are called "non-conductors" or "insulators;" and glass stands pre-eminently first, as from its coldness and smoothness it is entitled to do. When we wish to designate electricity as positive or negative, we do not write the words positive and negative, but we employ the mathematical signs—plus (+) for positive electricity, minus (−) for negative; and it is hardly necessary to say that this notation is of great advantage, and being generally accepted, saves us much trouble.

We use three varieties of electricity—not different kinds remember, but varieties only:—1. The oldest known form, and that which arises when any two substances are rubbed together, and hence called "*friction* electricity," and which is so conveniently generated by the rotation, by means of our gas engine, of a circular glass plate against a leather cushion or pad (see Fig. 2). 2. The electricity of chemical action the "continuous current," so called because the electricity *continues* to flow till the battery is exhausted. 3. The "induced current," so called because it exists only when *induced* by the last-mentioned current.

There is unfortunately much confusion in electrical names. "Galvanism" is commonly applied quite indiscriminately to all varieties of electricity, and I am afraid it will continue to be so; but recently the three varieties have been named after the three distinguished

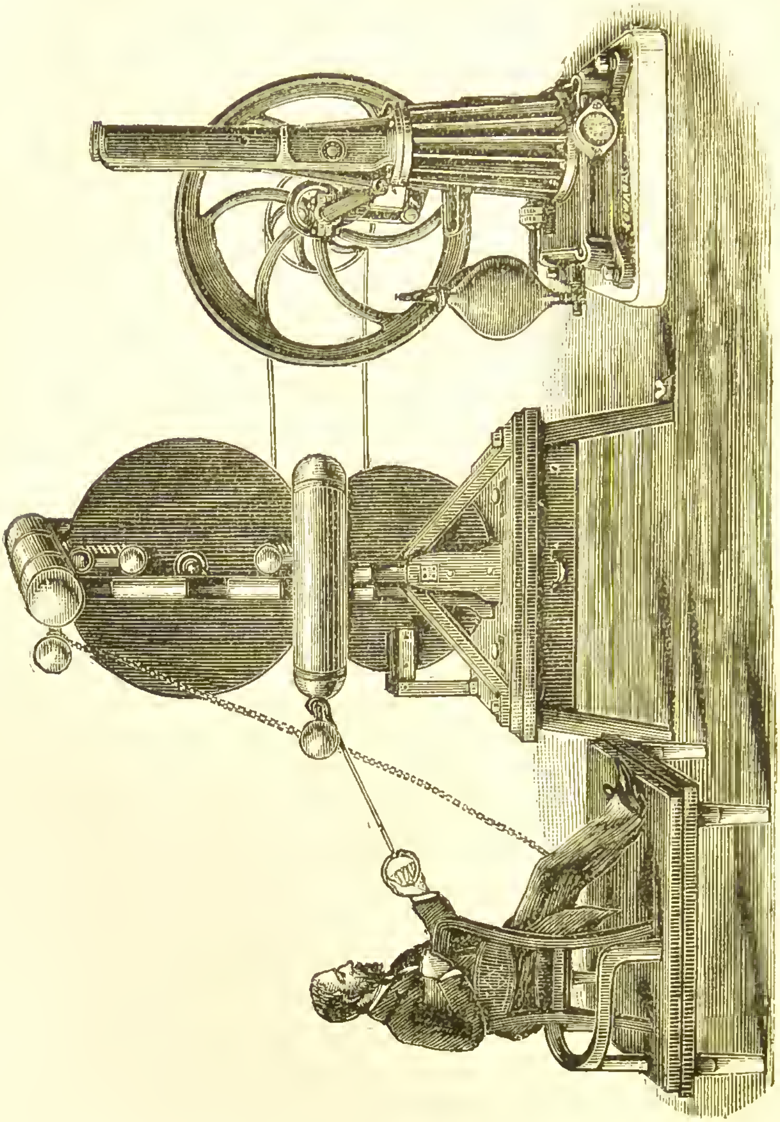

Fig. 2.—Machine with Gas Engine and Insulating Stool.

men chiefly associated with them, and I strongly advise you to so call them, and thus help to clear away the present uncertainty; for now, three people may write letters about what they call "Galvanism," and each of the three mean something different. Friction electricity is called "*Franklinism*," after Franklin. You have all heard the story of the thunder-cloud, the kite, the key tied to the kite-string, Franklin's disappointment that he obtained no electricity; its coming on to rain, and by wetting the string making it a conductor; and his delight at being then able to draw sparks, real miniature flashes of lightning, from the key with his knuckles! The continuous current is called "*Voltaism*," as Volta discovered it; and the induced current "*Faradism*," as it was discovered by Faraday.

As I told you, Franklinism arises whenever two substances are rubbed together; but most substances are conductors, and as quickly as electricity is produced it runs away to the ground. To prevent its doing this and to "store it up," so to say, we must hit upon some means by which production is largely in excess of escape, and this is fully accomplished by having our storehouse built upon a non-conducting foundation. Our accumulators (see Fig. 2) are our "storehouses"; and our insulating glass supports are their foundations. The electricity is rapidly stored up, and it cannot get away.

Voltaism is the result of chemical action. When two different metals are partially immersed in a liquid which is a good conductor of electricity, the two electricities (which you will recollect are always present in combination in every substance, and therefore of course in these metals) become separated; the positive electricity selects one metal and stops there; the negative electricity, similarly, the other metal. The two metals and fluid are called a "*galvanic element*," also a "*simple galvanic circuit*." The two metals, the fluid *not* included, are called the "*poles*" —that upon which the positive electricity has stored itself, the positive pole; the other, the negative pole. When the two poles are connected by a conductor the circuit is said to be "*closed*;" when not so connected it is said to be "*open*." When it is "closed" the electricities pass through the conductor and reunite. If you make yourself a part of this conductor, the electricities pass through you. This movement of the electricities is called the "*galvanic current*." Every electric current is, properly speaking, a double current: positive electricity flows in one direction, negative electricity in the opposite direction; but for the sake of clearness and brevity the positive current is designated simply as "*the* current," if the direction of the current is spoken of, it being always understood that an opposite current, the negative one, exists simultaneously. Thus, in a copper-zinc couple we should say *the current flows from the copper pole through the connecting wire to the zinc pole;* or, in other words, positive electricity flows from the copper through the connecting wire to the zinc; and negative electricity flows from the zinc through the connecting wire to the copper. Of course the fluid and metals must be contained in a jar or vessel of some sort, and the jar *with its contents* is called a "*cell*." When two elements are so arranged that the zinc of one element is in conducting connection with the copper or carbon of the other, twice as great an effect is produced as by a single element; and so on with *any* number of elements. The two or more elements thus united constitute a "*battery*"; but the word "battery," like the word "galvanism," is loosely used, sometimes meaning a single cell, and sometimes many. As in any battery the pole of one element is in connection with the opposite pole of the next, the terminal poles are the only free poles, and they are called the "*poles of the battery.*"

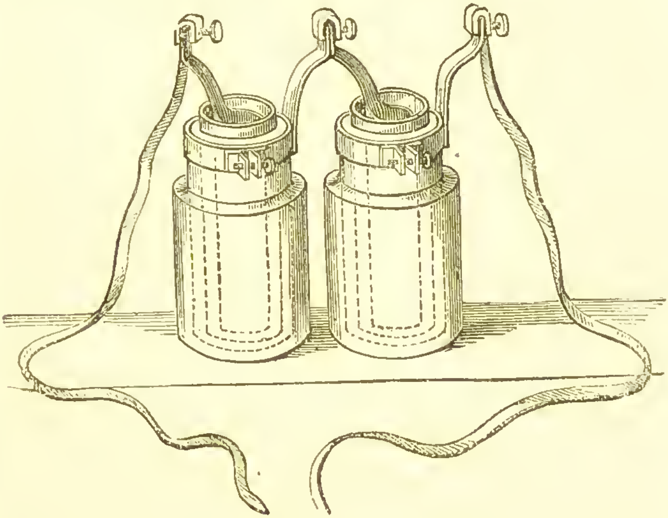

FIG. 3.—A Battery of Two Cells.

In Fig. 3 a battery of two cells is shown. You will observe the "elements"—viz., the fluid and the two metals; the "cell"—viz., the fluid, the two metals, and the earthenware vessel; and the "battery"—viz., the two cells with their free poles. This is all. This very simple arrangement has gone far to revolutionize the world. At any rate, it has given us electroplated spoons and bad half-crowns instead of silver, together with telegrams and other nuisances.

As the power of a battery depends upon the number of its cells, it ranges from a degree so weak that a delicately adjusted testing instrument may be needed to prove its existence, to a degree so great that care and circumspection are required to avoid danger. As illustrations, I may mention that when the first Atlantic cable was completed, Sir Charles Wheatstone borrowed a lady's thimble as the cell: the contained elements were a needle and a pin, the connecting wire was the sewing thread, and the exciting fluid a pinch of salt and a few drops of water. With the aid of this small battery he sent a telegram to America. On the other hand, in the early days of electric lighting more than one unfortunate workman came to an instantaneous death, owing to some fault in the machinery by which the current was passed through his body. Of course these batteries were infinitely more powerful than any we use; but in medical practice accidents have happened: one of the most eminent physicians in Europe permanently blinded a patient by suddenly applying a powerful current to his face; and we must therefore never allow familiarity with electricity to breed contempt, but always remember that we are using a power which, though potent for good, may become potent also for evil. Batteries may be either fixed or portable. Fixed batteries are easier to keep in order; portable ones enable you to visit patients at their own houses. A very common and useful cell is that called the "bichromate": the elements consist of carbon and zinc; the exciting fluid a solution of bichromate of potash in diluted sulphuric acid. When exhausted, you can easily re-charge it yourself, and it is especially fitted for use with Faradism; but as to Voltaic cells their name is legion. But for all practical purposes a cell named the Leclanché has superseded most others. I show you Leclanché cells, both large and small: the larger ones (almost always used for electric bells) you can re-charge yourself by adding a little sal-ammoniac and water: the smaller ones you will have to get re-charged by the maker. But even with daily use they ought not to require this more than once in from four to six months, depending upon the care which is taken of them.

Faradism differs altogether from the Voltaic current, and you will therefore not be surprised to learn that they cannot be used interchangeably as if they were identical remedies. Faraday found that if two wires stretched side by side, but not touching, and if he then transmitted a current of Voltaic electricity through one of them, that a momentary current appeared in the other, *but only for a moment;* but upon the discontinuance of the current in the first wire this momentary current re-appeared again in the second wire, but in a reverse direction. This is why Faradism is sometimes called the "secondary current," because it arises in the second wire. Please then remember the fundamental distinction between the so-called Voltaic and Faradaic currents; that the Voltaic current is really what it is called—viz., a continuous current or stream of constantly flowing electricity; but, on the other hand, the Faradaic current is misnamed, for it is not a current at all, but a series of *shocks* of electricity, repeated many times in a second, and passing alternately in reverse directions. With regard to the two wires, it is found more convenient in practice to wind them round two reels, so as to form two separate coils, and to place the one within the other, by which the power is much increased. Here are two coils. I place the one within the other, and I pass a rapid succession of Voltaic currents through it. The way in which I obtain this succession of currents is by a most clever invention known as the "electric hammer." Fig. 4 shows one of these coils; the other is inserted within it, and within this inserted coil is a bundle of thick iron wire. The letter A in the figure represents a Voltaic cell. You will observe that one conducting wire from it is joined to one end of the wire of the first coil; the second wire from it is joined to a needle *n′*, which can be protruded or retracted by a screw head. You see this needle *n′* is in contact in the figure with a steel spring *n″*, at the end of which is a little piece of iron E. This bit of iron is the electric hammer. The second end of the wire of the first coil is joined at *n″* to the spring and hammer. When the Voltaic cell A is put in action, the current passes through the coil in the direction shown in the figure by the arrows, necessarily circulating round the bundle of iron wire C. Now when a Voltaic current circulates around a piece of iron, it

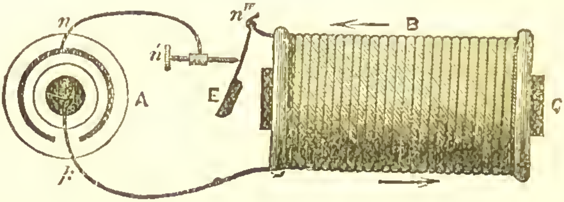

FIG. 4.—Diagram illustrating a Faradaic Coil.

turns that iron into a magnet, and we know that a magnet attracts iron. This newly formed magnet attracts the head E of the hammer with an attraction stronger than the power of the spring n'', *and the hammer flies to the magnet;* but this movement of the hammer detaches the spring from the needle-point, which leaves an open space, and stops the Voltaic current as completely as the cutting of a telegraph wire would stop a telegram. As the Voltaic current has been thus cut off, the bundle of iron wire C ceases to be a magnet—ceases therefore to attract the hammer, the spring of which becomes again the strongest, and back flies the hammer to the needle-point. But this return re-establishes the Voltaic current; and the same process is repeated, the hammer vibrating backwards and forwards, and each time it leaves the needle-point, and each time it regains it, a shock of Faradism traverses the second coil.

We thus see that many shocks, as many as some hundreds, may be administered in one second of time.

I now show you two Voltaic batteries.

Fig. 5 consists of Leclanché cells; Fig. 6 of bichromate cells. This latter is a convenient one for use in country districts, as it admits of the owner re-charging it himself. This, however, is a troublesome operation, and, when practicable, batteries required to be recharged had better be sent to the maker.*

Let us examine the battery shown in Fig. 5, which I designed, as from its general "build," if I may use the term, it will serve to illustrate the essential parts of any properly constructed medical battery. Its cells

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* All the instruments described in these Demonstrations may be obtained from Mr. Hawksley, surgical instrument maker, 357 Oxford Street, London, W. The batteries are known as "Dr. Tibbits' Medical Batteries."

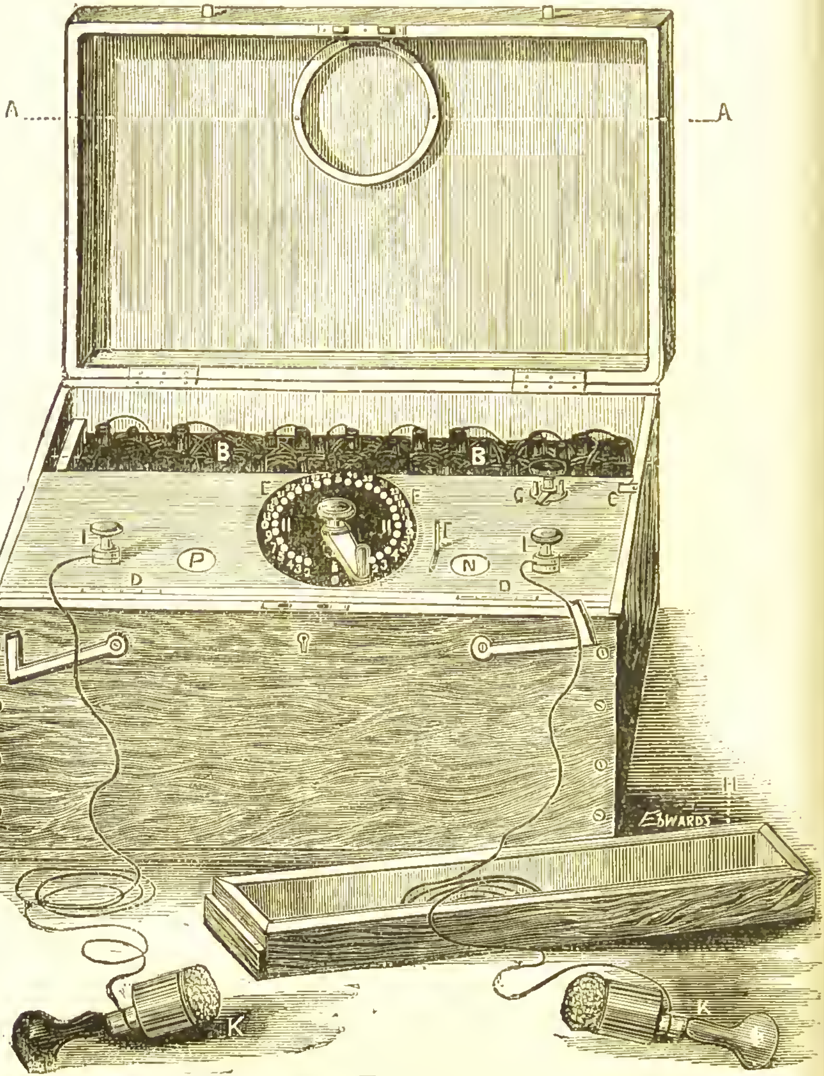

Fig. 5.

B B when in use are hidden from view, but they are shown in the figure by the receptacle for accessories, H having been removed. The board which is kept in place by the bolt C, and moves on the hinges D D, is called the "element board." The wires connecting the cells B B conduct their current through the graduating dial E, and the position of the needle of this dial determines from how many of the cells the electricity shall be allowed to reach the binding screws I I, and from them, by way of the conducting wires,

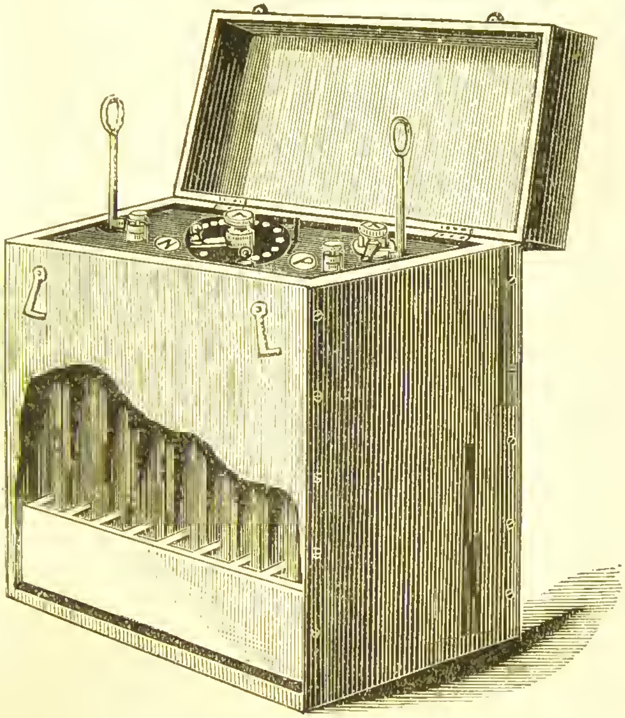

Fig. 6.

the sponge-holders K K; or whether it shall be entirely shut off, as is the case when the battery is not in use, and when the needle stands at O.

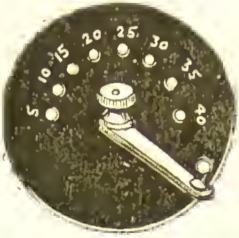

Fig. 7.

When the needle points to any stud numbered on the dial (an enlarged view of which is shown in Fig. 7), the number of cells marked on that stud are brought into action, and the needle is made just wide enough to touch one of the studs before it leaves the preceding one, and thus the current may be increased or decreased in power without shock, and while the conductors are held applied to the patient; but if it were not so made, a series of painful shocks would be felt whenever the current was increased or decreased. Should the needle, from forgetfulness, be left when out of use in any other position than at O, a guard A upon the lid of the instrument prevents its being shut, and the operator has his attention called to his inadvertence. A Voltaic alternative, or change of direction of the current, is sometimes required in treatment, and the commutator of the poles enables this to be accomplished without alteration in the position of the conductors. By pushing forwards or backwards the handle F, which moves a lever working below the element board, the current is instantly reversed, and the alternation of the letters P and N, seen through holes cut in the element board, indicates at once not only that there has been a change of poles, but which pole is at the moment negative or positive; whereas in all previous instruments, when the poles have been changed, there has either been no letter marking them, or this letter has really been wrong, and one has had to remember this; and under such circumstances, and examining patients in rapid succession, momentary confusion of the poles was very liable to occur, even to a practised operator. A key G enables the current to be shut off or on without removal of the conductors.

I now show you Faradaic batteries. An excellent one is that of Stöhrer of Dresden. Its cell is shown in Fig. 8; the elements are carbon and zinc. As you see, the zinc surrounds the carbon, and they are placed in a circular glass jar containing diluted sulphuric acid. In the completed apparatus the jar is so arranged that it can be moved vertically up and down, so that the acid can be brought into contact with the elements, or excluded from them altogether. I have designed an excellent bichromate Faradaic battery, which is simple, handy, and useful, and not liable to get out of order.

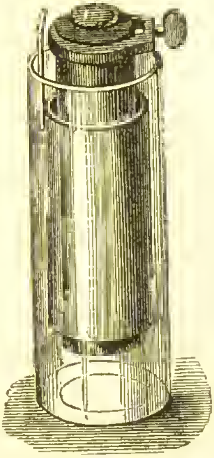

FIG. 8.

In Fig. 9 the front of the battery is cut away to show you the arrangement of the coils. You will observe that the graduator consists of a stem H, to which is attached the movable secondary coil L; in the figure this secondary coil is wholly withdrawn from the action of the primary K, and its strength depending entirely upon the extent to which it covers the primary, it is evident that the height which the graduator H stands above the element board will exactly indicate the strength.

An apparatus in which both varieties of electricity are combined is sometimes convenient, if it is so constructed that either the Voltaic current alone, or the

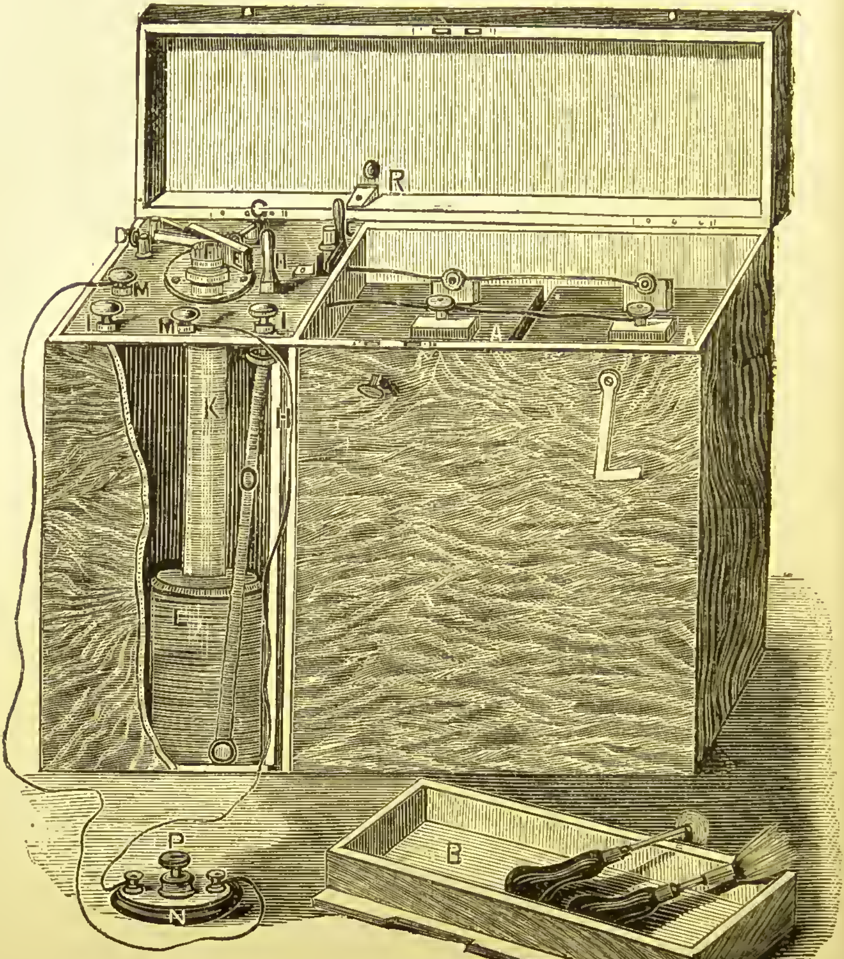

Fig. 9.

Faradaic alone, or the two united, can be brought into action as desired.

So much for batteries. Now for accessories.

The first necessary accessory is a conducting cord or wire, and it is of the first importance that this should really be what it is called, "a conductor," for any break of conduction in it will of course nullify the best and most perfect battery. It must also be sufficiently pliable and insulated by being coated with some non-conducting material, that the electricity may not escape from it to any conducting substance with which it may accidentally come into contact. The conducting cords sold by instrument-makers are sometimes not insulated at all, and then they are quite useless; but they are more commonly composed of several strands of metallic wire of about the diameter of sewing thread, the whole enclosed in some silken or woollen material, and nothing can be better than these latter when quite new. Their disadvantages are that they become frayed after a little use, and are liable to be constantly out of order, causing interruptions in the current; while they will only fit one kind of machine. I have had endless trouble with them; and for some years I have used nothing but thin copper wire, coated with gutta-percha in the same way as that known as "telegraph wire." This is perfectly insulated, sufficiently pliable for all purposes; it is cheap, and can be made to fit any sort of connection. Its one disadvantage is, that it is liable to break at the point where it is received into the terminals of the battery or the screw socket of the conductor. Should this happen, all that is necessary is to scrape off the gutta-percha coating with a pocket-knife for an inch from the broken end, by which we get practically a new conducting cord.

We have had some trouble with electricity, and we have had to discuss much dry but unavoidable detail.

Next week we will consider the bones, the muscles, the nerves, and the way to galvanize them.

DEMONSTRATION II.

As I told you last week, you *must* know *something* of the brain, the bones, the muscles and the nerves, before you can employ Medical Galvanism with either benefit to your patient or satisfaction to yourself, and I propose to-day to discuss these essential matters with you by the aid of these beautiful diagrams and plates. All the figures are drawn life-size from actual dissections, and they are printed in colours, with the object of making them as true pictures as possible of Nature.*

It was no part of my first intention to have given you, in this course of Demonstrations, any instruction in what I will call "*Electrical Anatomy;*" but in thinking out the best method of teaching you how to apply electricity, by which I mean, how to apply it *properly,* I have been met by difficulties at every step. That some practical knowledge of the mechanism and movements of the body *must* be acquired, I well knew, but I hoped that I should be able to recommend you some little book to efficiently help you to this knowledge. By the courtesy of several publishers, I have looked into some twenty books, and with the result that I find they all contain either much too little, or much too much, and I therefore feel obliged to do the best I can to impart the necessary knowledge to you myself.

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* The illustrations employed were the admirable life-size figures of the School of Science and Art, South Kensington, and the very beautiful life-size plates from dissections by Ellis and Ford. For the anatomical details, I refreshed my memory from Quain and Holden.

I shall discuss briefly—but as thoroughly as necessary—the anatomical details you *must* acquire; but I shall not even mention the viscera, arteries, veins and other structures of the body which are not of the *first* electrical importance.

I shall use familiar words wherever possible, but we cannot translate or change the technical names of certain bones, muscles and nerves.

Even surface-anatomy cannot be thoroughly learnt from description only; for some of our most distinguished artists have dissected the human body at a Medical School.

I wrote upon this matter, stating my difficulties to the Secretary of the London School of Medicine for Women,* and that lady has kindly replied that their customary fee will be reduced for students of Massage and Electricity who wish only to look on at the work of their dissecting-room, and to attend their demonstrations.

I strongly advise you to take advantage of this generous offer.

In health, as you know, the brain orders, the nerves convey orders, and the muscles, by using the bones, carry them out.

I now proceed to describe that framework of bones called the *Skeleton.** I shall use certain words with the meanings, which I now explain :—

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* 30 Henrietta Street, Brunswick Square, London, W.C.

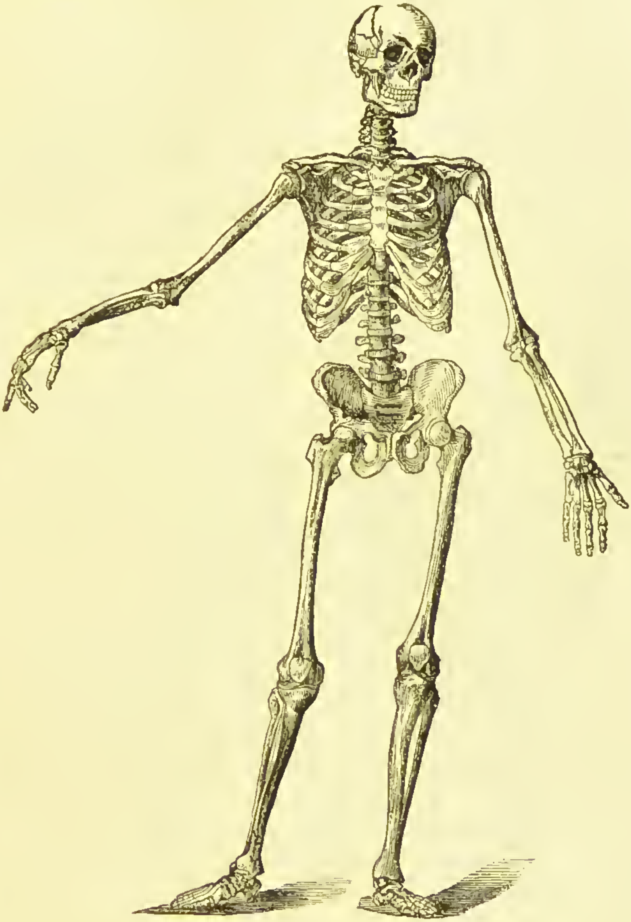

FIG. 10.—Front View of the Human Skeleton.

Cell.—A little bag or bladder containing fluid or other matter, and so minute that it can only be seen by the aid of a very powerful microscope. *It is believed that all living beings are developed from these little microscopic cells.*

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* The attention of the student is particularly directed to the prefatory note prefixed to these Demonstrations.

Tissue.—The intimate structure of any part.

Organ.—Any part of the body having a definite office to perform.

System.—The name given to all the organs of one kind.

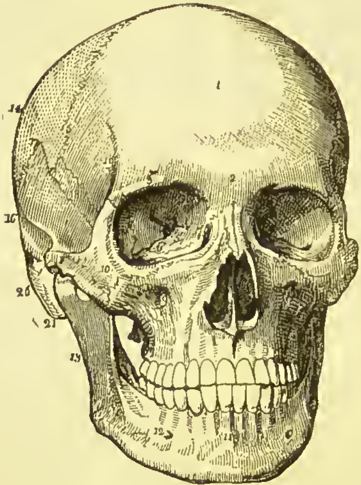

Fig. 11.—The Skull.

The Head.—The bony frame of the head is the skull. This consists of many bones strongly united together. Their chief use is to form an arched dome for the reception and protection of the brain and other important organs, as well as for the attachment of muscles.

The *Spine* is a column, formed of a series of bones called *Vertebræ.*[*] The essential peculiarities of a vertebra are a stout body in front and an arch behind. When the vertebræ are in their natural position, the arches form a continuous canal. Fig. 12 shows a vertebra seen from above; Fig. 13 one seen from the side.

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[*] There are about thirty separate vertebræ in the spine, and each has what may be called a buffer of gristle or cartilage, between it and its fellow, both above and below. I need not point out to you what a wonderful design this is for securing elasticity as well as strength, and for lessening shock.

The *Thorax*, or Chest, is a box made up of the bodies of twelve dorsal vertebræ behind, the sternum or breast-bone in front, and the ribs, twelve on each side.

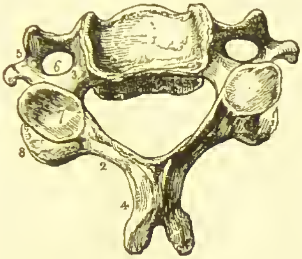

Fig. 12.
A Vertebra.

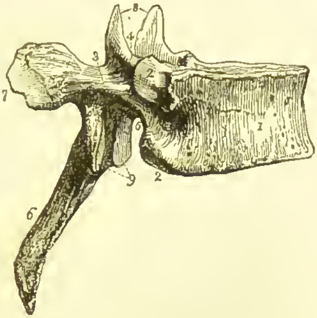

Fig. 13.
Side View of a Vertebra.

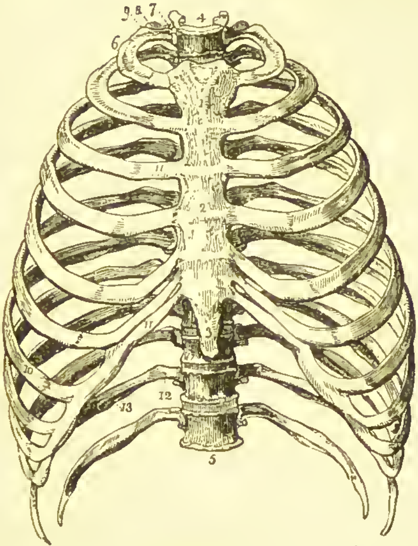

Fig. 14.—Breast-bone and Ribs.

All the ribs are jointed to the back-bone, and the upper seven to the breast-bone. *The Upper Extremity* consists of the arm, forearm and hand, and we may add the bones of the shoulder, the clavicle, or collar-bone, and the scapula, or shoulder-blade. The collar-bone is curved, and is well shown in Fig. 10—a front view of the human skeleton. Its inner end articulates with the top of the breast-bone, its outer with a point of the shoulder-blade called the *acromion.* The shoulder-blade (Fig. 15) is situated at the back of the shoulder, and it is somewhat triangular in shape. The arm-bone or humerus (Fig. 16), is a long bone, with a shaft, a rounded upper end or head, and a large lower end, made up of two prominences called the inner and outer con-

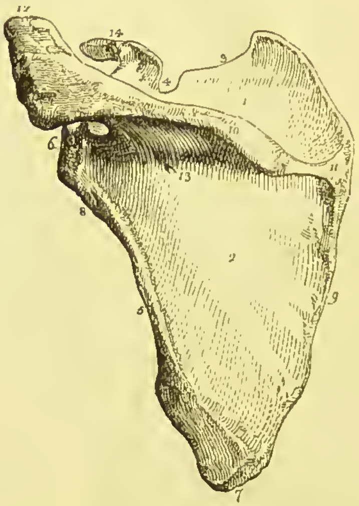

Fig. 15.—The Shoulder-blade.

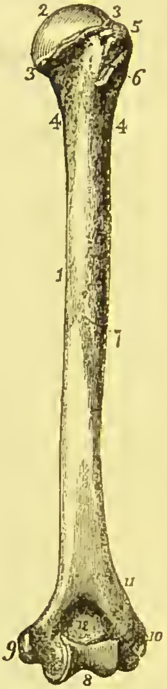

Fig. 16.—The Arm-bone.

dyles, between which is a pulley-like surface for articulation with the *ulna*, one of the bones of the forearm.

The *Forearm* (Fig. 17) has two bones: the *ulna* and the *radius*. The ulna forms the point of the elbow, and when the hand is held with its palm upwards it occupies the inner side of the forearm. From the upper end of the bones arise two prominences; that at the extreme end (popularly called the "Funny bone") is called *the olecranon*. The other, a little lower down, and on the front of the bone, is called the *coronoid* process. Between the two processes is a semilunar depression called the sigmoid cavity, by means of which the bone unites with the humerus to form the elbow-joint—*a hinge-joint motion*. The lower end of the ulna is quite small and rounded, and forms the prominence seen on the outside of the wrist when the back of the hand is held upwards. The radius is larger below, and forms the bulk of the wrist-joint. This end is slightly hollowed out, and the shallow cup thus formed allows the hand to move, by a gliding motion, not only to and fro as a hinge, but somewhat from side to side. The upper end of the radius is smaller, round, and with a prominent ridge like the head of a nail. This head articulates with the humerus and with the ulna.

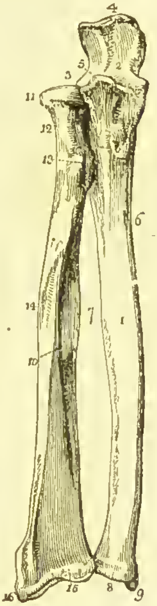

FIG. 17.—Left Ulna and Radius.

By means of this arrangement the peculiar power of turning the hand over is accomplished. Thus, when the hand is held palm upwards the two bones of the forearm are nearly parallel. When the palm is down the ulna has not changed its position, but the radius has revolved so as to cross the top of the ulna. (Compare the right forearm in Fig. 10 with the left.)

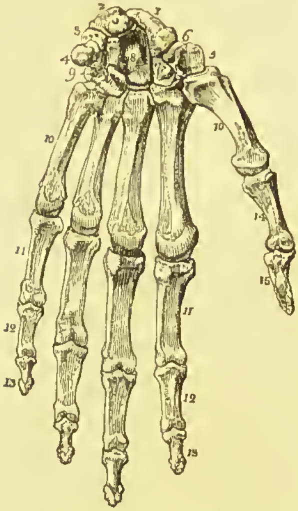

Fig. 18.—Wrist and Hand.

The *Carpus,* or Wrist, is composed of eight small bones in two rows. The body of the hand has one bone for the thumb, and one for each finger. The thumb has two bones called phalanges, one for each joint, and the fingers have each three bones.

The Lower Extremity consists of three parts, the thigh, the leg, and the foot. It is connected to the trunk by the haunch-bone, which bears the same relation to the lower extremity that the shoulder does to the upper.

The haunch-bone (*os innominatum*) is a very large, irregular flat bone, composed of three bones grown together (the *ilium,* the *ischium,* and the *pubes.*) The *ilium* is the upper and larger part of the whole bone. Its upper margin forms what is popularly called the *hip-bone* (see Fig. 19). The lower extremity of the haunch-bone is called the ischium or seat-bone. Upon the stout tuberosities of the ischium we sit. The remaining part of the haunch-bone is the pubis, meeting its fellow of the opposite side. The junction of the two haunch-bones with each other in front and with the *sacrum*—

a bone which is practically the termination of the spinal column—at the back forms the strong ring of bone which serves to support the trunk upon the lower extremities, and the cavity of this ring forms a kind of basin which contains important organs. The united bones are called the *pelvis*. In the middle of the united bone on each side is a deep cup-shaped depression called the *acetabulum*, the socket into which the head of the thigh-bone fits. (Compare Figs. 10 and 19.) The thigh has but a single bone, the *femur* (Fig. 20), the largest, longest and strongest bone in the skeleton.

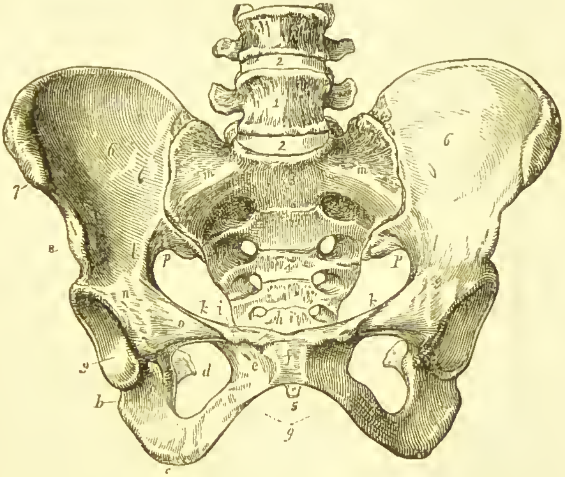

Fig. 19.—The Haunch-bones and Pelvis.

Its shaft is cylindrical. At the upper end are two prominences, one on the inner side called the lesser trochanter, the other on the outer side called the greater trochanter. The latter forms the bone felt just beneath the skin opposite the hip-joint. The neck proceeds from the shaft at an angle, and is surmounted by a rounded head which fits into the cup-shaped socket of the haunch-bone. The lower end of the thigh-bone is larger than the shaft, with an enlargement on either side termed a condyle. Between the two condyles is a deep notch. The head of the thigh-bone and the socket in the haunch form a "ball and socket joint;" the condyles are fitted only to enter into a hinge-joint, and it makes this hinge-joint with the principal bone of the leg, the tibia or shin-bone. (Fig. 23.)

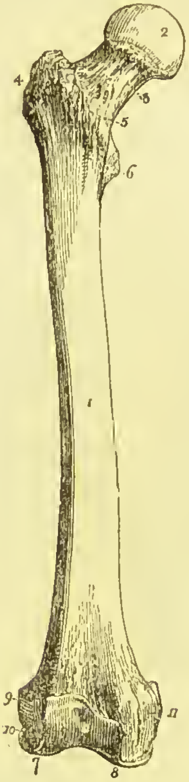

Fig. 20.—The Thigh-bone.

In the front of the knee-joint is an irregular disc-shaped bone, the *knee-pan* or *patella*. (Fig. 21.) This is developed in the tendon of the strong muscle, the *quadriceps extensor*, or great four-headed extender, of the leg. It serves to increase the leverage of the muscle, and to protect the front of the joint from injury.

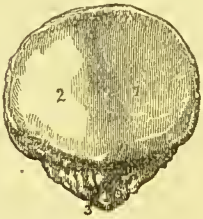

Fig. 21.—The Knee-pan.

The *Leg* has two bones—the *tibia*, or shin-bone, and the *fibula*, or splint-bone. They are about the same length, but the tibia is much the larger of the two. The upper extremity at the head of the tibia is quite large, having on the inner and outer side an enlargement called a tuberosity, and corresponding with the condyles of the femur in making up the hinge of the knee-joint. These tuberosities can be easily felt on either side of the leg just below the knee-joint; and in front between them will be noticed a small projection (the tubercle of the shin-bone), and to which is attached the great extensor of the leg. At its lower end the bone again becomes enlarged, and has a surface for articulation with the foot. From the inner end of this lower extremity a projection of bone extends downwards, and is called the malleolus—popularly the inner ankle-bone.

On the outer side of the tibia is the fibula (Fig. 22), a very slender bone.* Its upper end is placed against the outer tuberosity of the shin-bone, and its lower end lies against the outer side of the lower end of the tibia, but projects beyond it in such a manner as to form the outer ankle-bone.

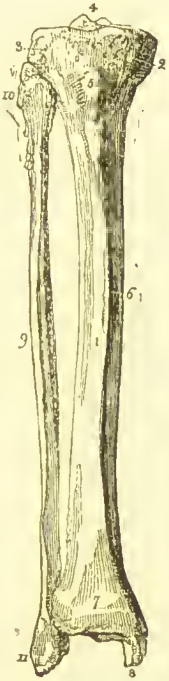

FIG. 22. The Fibula or Splint-bone. FIG. 23. The Tibia or Shin-bone.

The *Foot* (Fig. 24), like the hand, is made up of three divisions—tarsus, metatarsus, phalanges. The tarsus has seven bones, of which the largest is the *os*

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* The great statesman, Sir Robert Peel, was thrown from his horse and fractured this bone, and died from it. Probably a unique case of death from so slight an accident.

calcis, or heel-bone. It forms the heel, and is the posterior support of the foot, considered as an arch bearing the weight of the body; and by reason of its projection backwards beyond the ankle-joint, it forms a strong lever for the attachment of the muscles of the calf, which raise the heel in walking, &c. Another principal bone is the *astragalus*, lying on the forward part of the os calcis. It is this bone that works in a hinge-like manner against the shin-bone, and between the inner and outer ankle-bones, forming with them the ankle-joint. Its upper surface is smooth and pulley-like for forming this articulation. Running forwards are five metatarsal bones, one corresponding to each toe. The first bone, corresponding to the great toe, is much stouter than the others. Its larger end or head composes the largest part of the prominence of the great toe-joint. The phalanges are arranged like those of the hands—two for the great toe and three for each of the others.

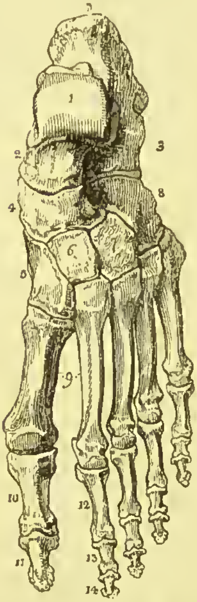

Fig. 24.—The Foot.

Every bone is connected with one or more others, and the connection is called a *Joint*, or an Articulation. The kinds of joints are very numerous. There may be simply dovetailing of bones, as in the skull, and so on to perfectly movable joints, the only kind with which we, as Electricians, are concerned; and these are chiefly hinge-joints, as the knee and elbow, and ball and socket or pivot-joints, as the shoulder and hip; also gliding joints, as the wrist-joint. The office of the joints is simple—viz., to permit of motion of one bone upon another, without which locomotion or any action of the body would be impossible.

To put our framework of bones into motion, other organs are demanded.

The large quantity of soft, reddish tissue which, under the skin, surrounds the bones, is called the *Flesh*. Closely examined, it is found to consist, not of one uniform mass, but to be arranged in many portions or layers of various shapes and sizes. These are called *Muscles*.

A muscle, then, is an organ consisting of fibres or bundles of fibres bound together, and possessing the power of shortening itself—" of contracting "—exactly as a piece of india-rubber will contract. If one end of a muscle is fixed to an immovable object and its other end to a movable one, and if it then shortens itself it draws the movable one to the fixed one. *This is the simple principle of all muscular movement*; and as there are 208 bones and about 400 muscles in our bodies, and as a muscle will contract in the 30,000 part of a minute, we need not be surprised at the rapidity of some of our movements. I now raise my hand to my face. This is brought about by the contraction of a muscle called the *biceps*. One end of this muscle is fixed to my shoulder; the other end to the radius, a bone of the forearm below the elbow-joint. When it contracts, my fixed shoulder declines to come down, and up flies my forearm, carrying the hand. *Why* this biceps contracts, and what makes it contract, are questions we will answer presently. Muscles also possess as well as contractility, what we may call *expansibility*—the property which enables them to elongate directly after their contraction. When I lower my hand from my face the biceps expands; but this has nothing to do with the return of my hand: that is brought about by the contraction of another muscle attached to the back of my shoulder, and called the *triceps,* its other end being attached to the ulna, the second bone of the forearm. My fixed shoulder again declines to move, so down goes my forearm and hand. *The triceps is the antagonist of the biceps,* executing a different movement, and this illustrates the most common arrangement of muscles. Each muscle has its antagonist. The biceps bends or "*flexes*" my forearm; the triceps straightens or "*extends*" it. Most muscles have two extremities of a fibrous or tendinous structure, and an intervening larger or "fleshy" portion, termed the "belly" of the muscle. The extremities are fixed, but the belly is more or less free; and it is by the contraction or shortening of this central portion that the movement of the limb or part is accomplished. The more fixed extremity of the muscle is called its "*origin;*" the more movable its "*insertion.*" In its contraction it changes in form, but it does not change in size; it is diminished longitudinally, but increased transversely, so that its actual bulk remains the same, although apparently (as in the contraction of the biceps) the muscle swells up and becomes enlarged.

Muscles are classed into—1. The *Voluntary.* 2. The *Involuntary.* 3. The *Mixed.* The voluntary muscles are under the control of the will; the involuntary muscles are independent of the will; the mixed muscles are those which are, to a certain extent, under the influence of the will, but still act independently of it, as in sleep, &c.

I may add that our old friends, the ancient

Romans, called our bundle of fibres a "muscle," because they thought it looked like a skinned mouse (*mus*, *musculus*).*

The muscles of the *Head* and *Face*, though numerous, are chiefly small, and concerned in the movements of the eyes, nose, mouth, &c. They are chiefly "muscles of expression."

In the neck, the chief muscle (considered electrically) extends from the top of the breast-bone and the inner end of the collar-bone to the bony prominence just behind the ear. This is the *sterno-mastoid*. It bows the head, and turns the face to the opposite side. The two muscles acting together bow the head. It forms a cord-like prominence in thin persons across

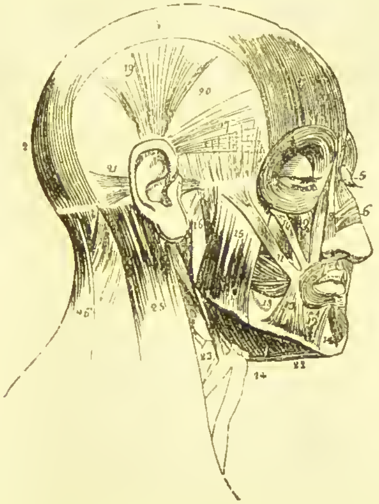

FIG. 25.—Muscles of the Head and Face.

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* The student is recommended to carefully examine an ordinary skinned rabbit, and to endeavour to find on its body muscles somewhat similar to those described on man.

the neck. If it be spasmodically contracted or its fellow paralyzed, the head will be twisted *from* the spasm or *to* the paralyzed side. This constitutes the deformity called "Wry Neck."

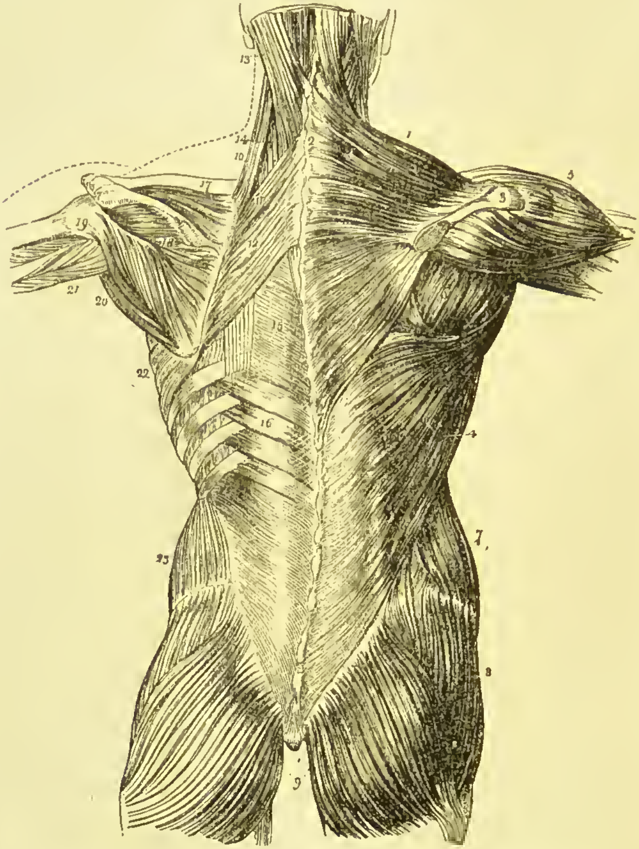

Fig. 26.—The Muscles of the Trunk—Back View.

The muscles of the *Trunk* are very numerous. Two only need detain us—the *trapezius* and the *latissimus dorsi*. The *trapezius* has a very extensive origin, almost from the head to the lower part of the spine. It is inserted into the spine of the scapula. If the head is fixed, it raises the point of the shoulder; if the shoulder is fixed, it bends the head towards the

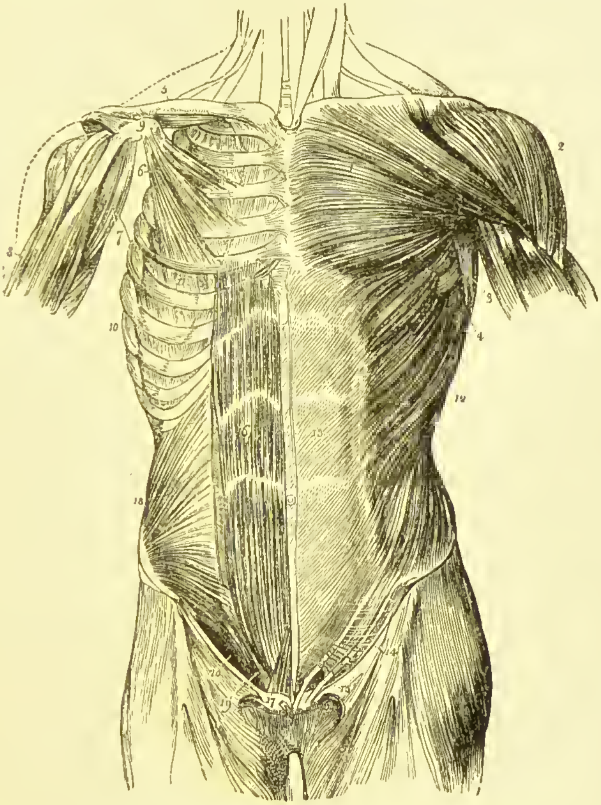

Fig. 27.—The Muscles of the Trunk—Front View.

shoulder; if both act, they throw the head backwards.

The *latissimus dorsi* covers the back below the trapezius. It arises from the lower part of the spine and the crest of the ilium, &c. From its extensive origin the fibres converge, are twisted upon themselves, and are inserted into the front of the arm-bone just below its head. The border of the muscle forms the posterior margin of the arm-pit; it draws the arm downwards and backwards and rolls it inwards. The act of putting the hand into the opposite tail coat-pocket shows its action.

The *Wall of the Abdomen* is made up chiefly of muscles. The central part of the wall contains the two *recti* ("*straight*" muscles), one on either side of the central line. They arise from the pubic bone below, and, running directly upwards, are inserted into the cartilages of the fifth, sixth, and seventh ribs. The remaining part of the front and sides of the abdominal wall is made up of three muscles which lie in layers; but they need not detain us.

The abdominal muscles act as follows:—If the chest and pelvis are fixed they assist to expel the contents of the stomach, as in vomiting; of the bowels in defecation; and of the bladder. If the spine is fixed they may assist in expiration; also bow the trunk forwards; and in climbing draw up the pelvis.

Muscles of the Upper Extremity.—The rotundity of the breast is chiefly made up of the *great pectoral muscle.* Its broad origin runs along the inner half of the collar-bone, down the breast-bone, along the cartilages of all the true ribs, &c. The fibres converge towards the upper part of the arm-bone, and form the front of the arm-pit, as may be easily made out by feeling this edge while the arm is forcibly drawn to the chest. The muscle is inserted into the front of the arm-bone just below its neck. Its action is to draw the arm inwards and across the chest, and to draw the shoulder downwards, if raised.

The round cap of the shoulder is made up of the *deltoid* muscle. It arises from the outer part of the collar-bone and the acromion process of the spine of the shoulder-blade, and is inserted into the outside and middle of the arm-bone. The muscle raises the arm directly outward from the side until it is level with the shoulder.

The front of the arm is made up chiefly by the biceps as a flexor of the forearm, with its assistant muscles. The great opponent of these muscles, the muscle which straightens the arm as in striking, is the triceps.

The *forearm* has some twenty muscles. If the hand be held palm upwards, the outside of the forearm is full and round at its upper part. This is due to the *long supinator*. It turns the forearm upon its back—in other words, supinates it. The hand is *pronated*—that is, turned palm downwards by antagonist muscles. In the middle of the wrist two tendons are generally prominent. That near the thumb is the tendon of the *radial flexor of the wrist;* the other, that of the *long palmar* muscle, which makes tense the palm of the hand and assists in flexing the wrist. The *ulnar flexor of the wrist* occupies the extreme *ulnar side* of the forearm. Beneath these muscles is the *superficial flexor of the fingers.* It has four tendons, one for each finger, inserted into the second bones of the fingers. These tendons are split opposite the first bones, and form arches or grooves through which pass the tendons of the deep flexors of the fingers to the last bones of the fingers. The thumb is supplied with flexors of its own.

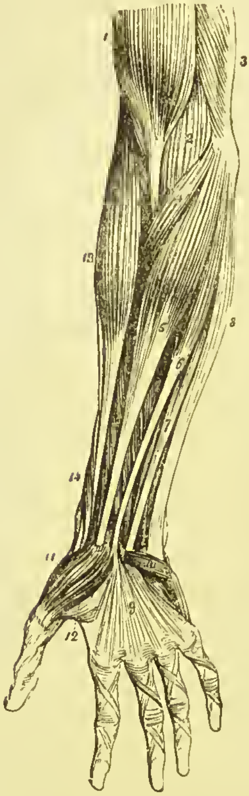

Fig. 28.—Muscles of Front of Forearm and Hand.

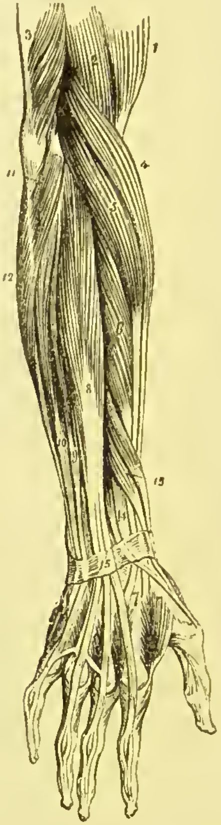

Fig. 29.—Muscles of Back of Forearm and Hand.

On the back of the forearm is the *long radial extensor of the wrist.* Its tendon is inserted into the radial side of the metacarpal bone of the first finger.

There is a shorter muscle just below it inserted into the second finger. Down the middle of the back of the forearm runs the *common extensor of the fingers.* Its divided tendons are inserted into the second and third bones of all the fingers. This muscle straightens the fingers when bent, and by contracting strongly will bend them backwards. Beside it, to the inner side, is the *extensor of the little finger.* Still further inward, and forming the ulnar border of the forearm, is the *ulnar extensor of the wrist,* its tendon inserted into the metacarpal bone of the little finger. All the tendons that pass from the forearm to the hand are bound down at the wrist by the *annular ligament,* a strong fibrous band encircling the wrist.

The muscles of the hand are divided into those of the thumb, those of the little finger, and those of the palm. The "ball of the thumb" is made up of four muscles—drawing it outwards, inwards, flexing it, and drawing it towards the hand. The little finger has also its special muscles, and between the bones of the hand are two groups of muscles. Those on the back of the hand spread the fingers apart; those on the palmar side bring them together.

The *Muscles of the Lower Extremity* include those of the hip, thigh, leg, and foot, and the flexors of the thigh arising within the cavity of the trunk. The flexors of the thigh are the *great psoas* and the *internal iliac* muscles. The psoas arises from the sides of the last dorsal and all the lumbar vertebræ; the iliac from the great hollow on the inside of the haunch-bone. The two muscles have a common tendon inserted into the lesser trochanter of the thigh-bone. It raises the thigh, and rolls it a little outwards.

If the thighs are fixed, it bends the small of the back forwards.

The muscles of the hip are the three *gluteals*, with accessory muscles. The back of the buttock is made

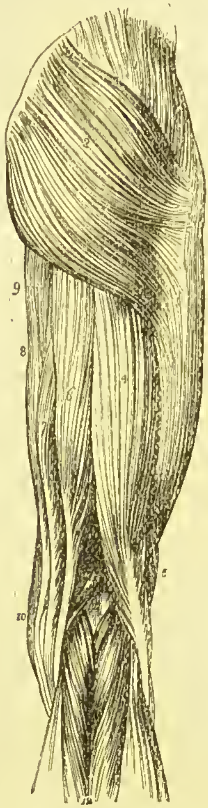

Fig. 30.—Back View of the Muscles of the Hip and Thigh.

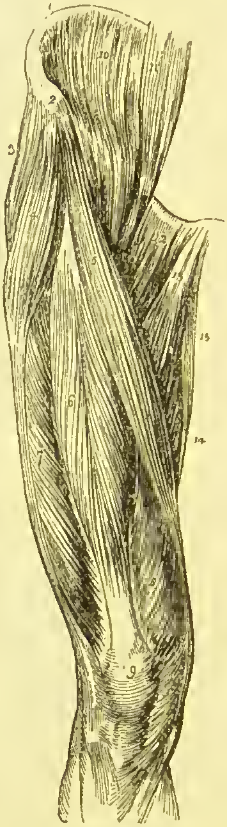

Fig. 31.—Front View of the Muscles of the Hip and Thigh.

up of the *great gluteal*, which arises from the back part of the crest of the ilium and from the sacrum, and it is inserted into the back of the upper part of the thigh-bone below the great trochanter. It is a very powerful muscle.

The gluteal muscles acting together move the thigh outwards; the anterior part of them roll it inwards; the posterior part roll it outwards; the lesser gluteal muscle draws the thigh forwards and up; the greater draws it backwards and straightens it. They all, acting together, also steady the trunk on the thighs, and raise the trunk from a stooping posture. The other muscles roll the thigh outwards, or draw it outwards if in a sitting posture.

The muscles of the thigh proper are for the most part large and strong. The longest muscle in the body is the *sartorius*, or "Tailor's Muscle;" so-called because its action is to crook the lower limb, as does a tailor when he sits cross-legged. The front of the thigh is made up of the great *four-headed extensor*. It is called "four-headed" because it is made up of the *rectus*, or straight muscle, occupying the middle of the thigh, the inner and outer *vasti* lying at either side, and wrapping around the thigh-bone, and of the *crureus*, a part of the internal vastus. All these masses of muscular tissue have a common tendon inserted into the knee-cap and tibia.

The muscles on the inner side of the thigh are *adductors*. The back of the thigh is made up of the hamstring muscles. The outer hamstring is the tendon of the strong *biceps* muscle, which arises from the seat-bone and the thigh-bone. This muscle is inserted into the head of the *fibula* or splint-bone, the smaller bone of the leg. The tendon of the inner hamstring muscle is inserted into the inner side of the upper part of the shin-bone. The hamstring muscles flex the leg upon the thigh. The biceps also twists the leg outwards. On the inner side of the *leg* the shin-bone lies just beneath the skin; but its outer aspect is covered for about two-thirds by the belly of the anterior tibial muscle. Its tendon is inserted into the head of the first metatarsal bone. Its tendon can be

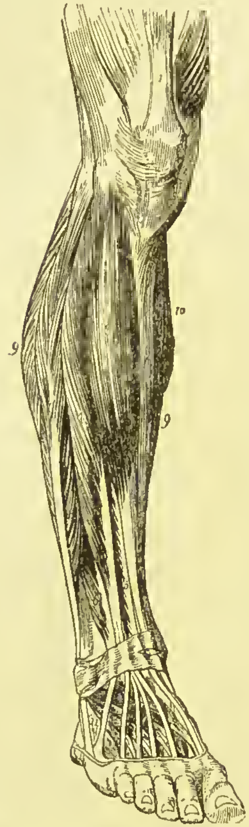

Fig. 32.—Front View of the Muscles of the Leg and Foot.

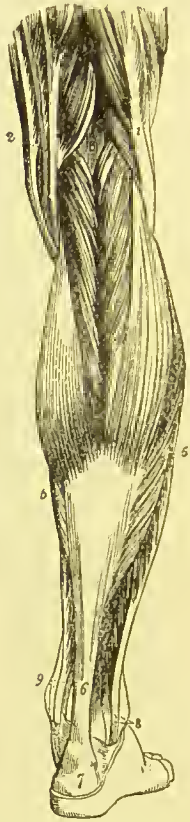

Fig. 33.—Back View of the Muscles of the Leg and Foot.

felt crossing in front of the ankle, to the hollow of the foot. It raises the front of the foot and rolls its inner border upward. Next outside is the long extensor of the toes, with four tendons arranged in the same manner as the extensor of the fingers. Underneath is the *proper extensor of the great toe.*

The back of the leg or calf is made up of the *gastrocnemius* and *soleus,* having a common tendon, the *tendo-Achillis* or heel cord. The gastrocnemius arises by two heads from the back part of the condyles of the femur, and the soleus is underneath. The stout common tendon is inserted into the bone of the heel. The combined muscle raises the heel, and is used in walking, jumping, &c. In standing it steadies the thigh upon the leg. Deeper in the calf lie *the long flexor of the great toe* to the outside; *the long flexor of the toes* to the inside; and between them the *posterior tibial muscle.* The two former go to the toes in a manner similar to that described when speaking of the flexors of the fingers. The tibials and the peroneals have an action analogous to that of the flexors and extensors of the wrist. Beneath the sole of the foot is the *short flexor of the toes,* with four tendons. These are inserted into the second phalanges, and are perforated by the tendons of the *long flexor,* as in the

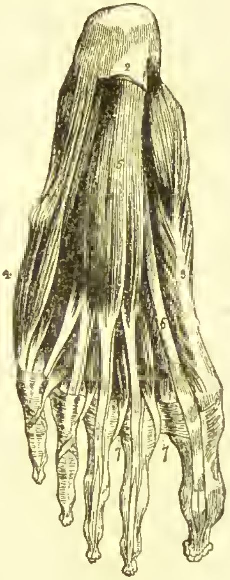

FIG. 34.—Muscles of the Foot.

hand. There is also an abductor of the great toe, and an abductor of the little toe. There is only one muscle on the back of the foot—*the short extensor of* the toes.

You will have observed how much the upper and lower limbs resemble each other in their general plan. The arm corresponds with the thigh, the forearm with the leg, the hand with the foot; modified, of course, to suit their different uses—one being for prehension, or grasping, the other for support and locomotion.

Now let us recapitulate for a moment. We have discussed the bones from *a purely mechanical point of view*—some of them as levers, others as being hollowed into pulleys, some as hinges, others as ball-and-socket joints, regarding the muscles merely as so many ropes or elastic bands attached to these bones. In fact, we might have been mechanics having to do with a machine ready fitted for work, *but waiting for the power to work it.* We did not remember that these bones are in our bodies *living things*—not as we see them after death, dead and white and dry, but living and red and moist and bleeding if cut, and capable of becoming acutely painful; and that our muscles, though apparently inert and at rest, are like so many soldiers standing "at attention," ready to obey the word of command.

Suddenly that word is given, and the muscles become all active! WHY?

To answer this question we must study the most important factor in animal life—the NERVOUS SYSTEM.

Man surpasses all other animals by possessing a nervous system, altogether unapproached in the perfection of its structure and action.

It consists of a collection of organs through which our impressions are received, and by means of which the action of all other organs is controlled.

There are two great divisions :—

1. *The cerebro-spinal system*, including the brain and spinal cord and the nerves directly arising from them. This system presides over sensation, voluntary motion, the INTELLECT, and all the functions generally described as belonging to animal life.

2. *The sympathetic system*, composed of what are called "*ganglia*," situated in most parts of the body, and nerves arising from them. A ganglion is a collection or enlargement of nervous material resembling a knot. This system presides over what are called the vegetative functions—the functions of nutrition and growth.

Nerve tissue consists of nerve cells, which generate what is called "*nerve force*," and nerve *fibres*, which conduct that force.

The spinal cord occupies the canal of the spinal column. It is about sixteen inches long, and breaks up towards the lower part of the spine into a bundle of nerves called the "horse's tail" (*cauda equina*). In the neck and lower part of the back it is enlarged, and from these enlargements are given off the nerves for the upper and lower extremities. The cord acts, firstly, as a conductor. It conducts the stimulus from the brain to the muscles, and it carries back sensory impressions to the brain. It acts, secondly, as a producer of what are called *reflex* actions ; that is, actions which are produced unconsciously. If you cut off a fowl's head it will run for some distance. This is reflex action, for its head having been removed it cannot be a conscious or voluntary action. Opposite each opening in the spinal column a spinal nerve is given off on each side of the cord. It arises by two roots, an anterior and a posterior, the latter having an enlargement upon it again, called a ganglion. The anterior roots conduct only motor stimuli; the posterior only sensory impressions. The two almost immediately unite and form a single nerve called a "*mixed* nerve," that is, both motor and sensory; and all the branches of this nerve preserve this mixed character.

Nerve force is not *identical* with any other known force. *Is it electricity?* It travels along a nerve at the rate of about 110 feet a second. Electricity, you will recollect, travels at 280,000 miles a second through a copper wire; but this is not a conclusive negative!

Through these "mixed" nerves, we are able to move at will any part of the body furnished with voluntary muscles; but we find it difficult to execute some movements without including certain others not intended. These are called "associated movements." Thus the last three fingers are apt to all move together, yet they can be moved singly. Again, it is difficult to use the two hands in dissimilar ways (as, for instance, in the child's feat of rubbing the head with a circular motion of one hand and patting the stomach with the other), keen concentration of attention being required to prevent the second hand imitating the motions of the first.

The brain fills the cavity of the skull. It is divided into four principal parts: the *cerebrum*, or great brain; the *cerebellum*, or little brain: the *pons Varolii* (bridge of Varolius); and the *medulla oblongata*, or long marrow. The cerebrum is the organ of the mind; the cerebellum regulates or co-ordinates muscular movements generally; the pons probably regulates certain automatic movements, such as standing or walking, and the medulla especially presides over respiration. In execution by hanging it is the injury of this part of the brain which is especially sought, that death may be instantaneous and painless.

The nerves that pass out of the cavity of the cranium are called the *cranial* nerves. Some of them supply the special senses of smell, sight and hearing. Others are distributed to the muscles of the face and head, and one of them, a very important one (the pneumogastric) is concerned in the act of swallowing, in breathing, in regulating the motions of the heart, and the movements of the stomach in digestion.

There are thirty-one *spinal* nerves: eight cervical, twelve dorsal, five lumbar, six sacral.

The anterior roots of the upper four nerves of the neck are connected to form the *cervical plexus*. The branches of this plexus are quite numerous. The most important is the *phrenic* nerve, the chief nerve of respiration.

The anterior branches of the fifth, sixth and seventh nerves of the neck unite. Those of the eighth cervical and first dorsal unite. The two large nerves thus formed throw off fibres to unite and form a third cord called the posterior. This arrangement of nerves is called the "*brachial*" *plexus*. The three cords proceed down the middle of the armpit, and at its lower part they break up into the nerves of the upper extremity. The three largest branches are the *ulnar*, *median*, and *musculo-spiral*. The ulnar passes down the inner side of the arm, and ultimately supplies the little finger and the adjoining surface of the ring finger. The median courses to the elbow; thence down the middle of the forearm, and supplies the thumb, and those

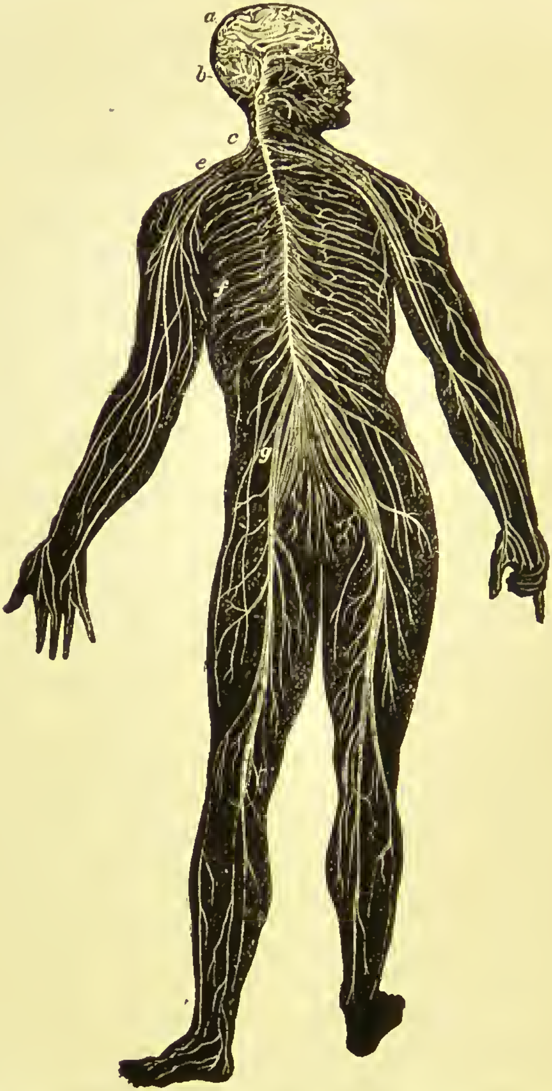

Fig. 35.—Diagram of the "Cerebro-spinal Nervous System."

[The student is recommended to study this figure carefully through a magnifying glass, and to endeavour to recognize the nerves, &c., mentioned in the text.]

fingers not supplied by the ulnar. The musculo-spiral supplies the back of the arm and forearm. All these nerves supply both muscles and skin.

In the dorsal region twelve dorsal nerves are given off on each side. The posterior branches supply the muscles and integuments of the back. The anterior branches run between the ribs, and are termed inter-costal nerves.

In the lumbar region five nerves are given off, their posterior branches, like the preceding nerves, going to the back. The anterior branches unite to form a plexus, which sends branches to the walls of the abdomen, and to the lower extremities. By far the largest branch is the *anterior crural nerve*, which passes into the thigh. It supplies the front and inner side of the thigh, leg and foot.

There are five sacral nerves, a part of which go to form the *sacral plexus.* The most important branch of this plexus is the great sciatic nerve, which runs down the middle of the back of the thigh and leg, and is finally distributed to the sole of the foot. Just above the knee the sciatic divides, sending a branch called the *peroneal* to the outer side of the leg. The other branch (practically a continuation of the main trunk) is called the internal *popliteal* nerve, which, below the popliteus muscle, again changes its name to the *posterior tibial* nerve. Its branches in the sole are the *internal* and *external plantar nerves.*

THE SYMPATHETIC SYSTEM.—As I have already explained, this is made up of ganglia and connecting nerves. The *ganglia* are found in the head, neck, chest and abdomen. They are arranged in pairs, except at the extremity of the spinal column, where there is but one. Besides being connected with one another, they are connected by numerous fibres to the nerves of the cerebro-spinal system. Owing to this intricate intermingling the problem of determining the exact functions of such nerves becomes more difficult. For example, behind the stomach lies the *solar plexus,* which gives rise to a large number of other plexuses. It is so important as to have sometimes been called the "*abdominal brain.*" As I have already stated, the sympathetic system presides over nutrition and growth, but its exact functions are but little proved. That it is, however, intimately connected with the brain is shown by the fact that organs under its control are powerfully influenced by mental

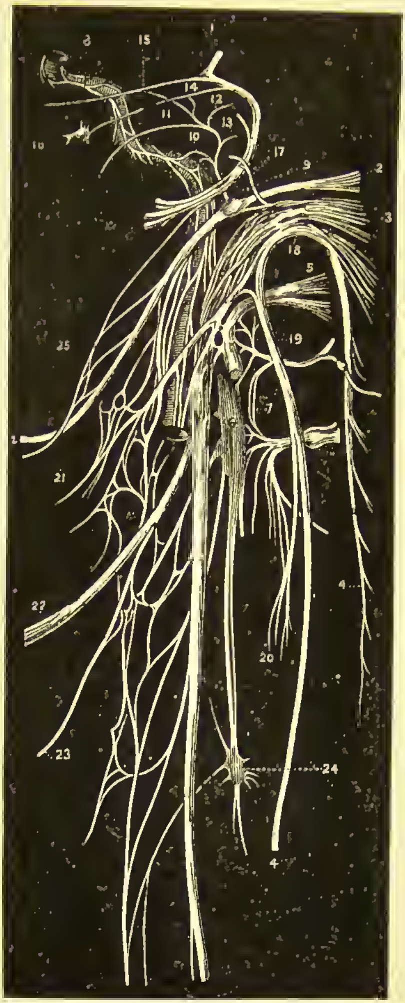

Fig. 36.—Figure from Nature, illustrating the " Sympathetic Nervous System " and also the intimate *interweaving* of the Nerves of the two Systems.

impressions. Under fear or despondency, the stomach will reject its food, or cease to digest it, and similarly the heart will beat more rapidly on the receipt of good news, or flutter, or perhaps stop altogether, on learning a great misfortune. Only yesterday a melancholy example was published in the *Times*. An unfortunate little boy, seven years old, overbalanced himself and fell from the gallery of a theatre, and his brother, eleven years old, was so affected that he fell down dead.

I am sorry to have detained you so long over these anatomical details, but when we come to study the direct application of electricity to the nerves you will acknowledge that our time has not been wasted.

METHODS OF APPLYING ELECTRICITY.

It is commonly said that electricity may be applied either generally or locally; but there is, strictly speaking, only one really *general* application—Electrization by Franklinism—in which the patient, sitting upon an insulated chair, or reclining on an insulated couch, is "charged" from a Static Machine. (See Fig. 2, p. 10.) We may administer the "simple charge," either positive or negative, by connecting the patient with the positive or negative accumulator, as the case may be, and allowing the electricity to saturate him, so to say. It gradually escapes from all parts of his body, being conducted away by the degree of moisture always present in the atmosphere, and as it escapes the revolving glass plate renews the supply. There is no shock; indeed, there is no sensation, and this is the most pleasant mode of administering electricity. If we desire to somewhat localize this escape along the course of certain nerves or otherwise, but still to avoid shock, we employ a conductor made of wood, and terminating in a number of small wooden points, which we slowly pass almost, but not quite, in contact with the skin. A luminous glow results, and the electricity rapidly escaping, generates a current of cold air perceptible to the patient. If we desire to administer a *slight* shock we use a similar conductor, but made of metal instead of wood. The application of the single point will cause a greater shock, our own knuckles a still greater, and a metallic ball the greatest of all. In all these shock applications a rapid succession of "sparks" passes from the patient to the conductor. This mode of electrization is therefore called "*Electrization by Sparks.*" Within certain limits, the larger the ball the more intense the spark. We can also further graduate our dose by tightening or loosening the cushions of the machine, as well as by increasing or decreasing the rapidity with which we allow the fly-wheel of our gas-engine and our glass-plate to revolve. This variety of electricity was discovered many centuries before Christ, by rubbing a piece of amber as I now rub this piece of glass. You see the divergence of the leaves of the electroscope, proving the existence of active electricity. It is very interesting that in our "*simple charge,*" when the electricity is escaping without the patient feeling anything, its presence is proved by the electroscope, placed many yards from the patient—in fact, at any part of the room. I shall demonstrate this after our lecture. For 2000 years after Franklinism was discovered no further progress was made; but Dr. Gilbert in 1600, Robert Boyle in

1675, Sir Isaac Newton and others, gradually developed it, and it was employed in medical practice nearly 100 years ago; so that our great-grandfathers were not the fools we are accustomed to think them. It afterwards fell into unmerited disuse, owing to the very imperfect instruments then obtainable so frequently "striking work!" Indeed, it is only quite recently that efficient apparatus has enabled treatment to be carried out with precision and success. I have further improved our Plate Machine, by having attached to it a second accumulator—the first time, I am led to understand, that such an addition has been made. This enables us to charge our patients with either positive or negative Franklinism—a matter sometimes of much importance, and which has hitherto been entirely ignored in this country.

As I have said, the "Franklinic charge" is the only method by which it is possible to simultaneously electrize the whole body.

The nearest approach to this *thorough* electrization is found in the Electric Bath.

This is an elegant and pleasant mode of administering electricity, when it is desired to obtain general effects. It cannot be made a strictly general application, because the head must be above water. Either the Voltaic or induced current may be used. A bath, sufficiently large for the patient to recline in it, should be fitted with insulating glass supports, and filled with water at a temperature of from 95 to 100 degrees. A zinc plate, measuring about 12 by 8 inches, and $\frac{1}{16}$th of an inch thick, in connection with one pole of the battery, may be inserted at the head, and a second carbon plate in connection with the other pole at the foot of the bath. The patient should be protected from direct contact with either plate by a smooth and open wooden framework. With a sufficiently powerful current a portion of the electricity will pass through the body of the patient reclining thus between the poles; but for this method of administration stronger currents of electricity are required than for ordinary applications, and the bath should preferably be made of some material, such as wood, slate, or marble, which is a worse conductor than the human body. This, however, is not necessary, when a part of the body not immersed in the bath is connected with one of the poles and the water with the other. Then currents of ordinary strength are amply sufficient. It is convenient in this form of bath for the patient to grasp in his unimmersed hands a copper bar covered with wet flannel and in connection with the second pole of the battery.

A very excellent method of administration is to place the zinc plate at the foot of the bath, or between the ankles, and to pass the carbon plate, which should measure about 15 inches long by 3 inches wide and ¾ths of an inch thick, slowly along, almost but not quite in contact with the skin, over the limbs, abdomen, spine, or any part of the body through which it is desired to conduct the current of electricity.

Several "Electric Bath" establishments exist in London, and there are few practitioners whose patients do not now and again bring them wonderful tales of marvellous cures from their use, and ask to be allowed to try them. Such patients should be instructed how to take an electric bath in their own bath or bedrooms, under the direction of their own medical adviser; and there is the less reason for letting them run the risk of unscientific and perhaps injurious treatment, now that reliable batteries can be obtained which act almost automatically, and require so little care to maintain them efficient. Again, to localize electricity technical knowledge is required; but any servant of ordinary capacity can administer an electric bath, if *cautioned explicitly as to the power of current to be employed.*

A convenient method of giving what may be called a "Semi-Bath" is to insert the feet and hands of the patient, or one foot and one hand, as the case may be, in separate vessels containing tepid salt and water, with which the conducting wires of the battery are in contact, the current being allowed to circulate during the time required. Ordinary foot-pails, basins, or jugs, will fulfil every requirement; while thick telegraph wire answers well to connect the battery with the vessels of water, as it is little liable to break and wears well.

Another application is that introduced by Beard and Rockwell, the American Electricians, under the name of "General Faradization." The patient sits with his naked feet upon a sheet of copper connected with one pole, while the other pole is connected by a moistened sponge with the left hand of the operator, who passes his disengaged hand, slightly moistened, over the muscles of the patient, and sometimes over his whole body. The current, I need hardly say, passes through the body of the operator before it reaches the patient, and the sensation he feels is his chief guide to its graduation. Another general application is the "Centralized Galvanization," of the same authors, in which their object is to bring the whole central nervous system under the influence of the Voltaic current. They place one pole—usually the negative—at the pit of the stomach and pass a large moistened sponge from the positive pole over the forehead and top of the head, and down the entire length of the spine, from the nape of the neck downwards.

For all the applications I have just demonstrated, the Voltaic or the Faradaic current, or both together, may be employed. To employ both together, take a piece of wire—say about 3 feet long; 6 or 8 inches from its end, attach a second wire, 6 or 8 inches long, and connect these two terminals, one to a pole of your Voltaic, the other to a pole of your Faradaic instrument. Do the same with a second wire, and attach its terminals to the remaining poles. My colleague, Dr. Dowse, advocates the occasional use of the different forms of electricity *simultaneously with the different processes of Massage*, the current being passed through the body of the Masseur or Masseuse, as in Beard and Rockwell's method. If the Masseur requires both hands at liberty, the battery connection may be made by a moistened sponge tied or buckled round the Masseur's upper arm.

But the great majority of cases require, not a generalized, but a strictly localized application, and for the fundamental principles of all methods of localized electrization we are indebted to the late Dr. Duchenne (the "father of electro-therapeutics"); for before him no one had attempted any local application of electricity that could properly be so called. Duchenne's two test experiments, demonstrating the fundamental principles of his method, I will now repeat upon the posterior surface of my left forearm. I propose to arrest Faradism in the skin, without allowing it to stimulate the subjacent muscles. To do this it is necessary for the skin to be quite dry—moisture, as you know, being a conductor of electricity—and to make sure of sufficient dryness, I sprinkle the skin with a little starch powder. I now apply to the dry skin the dry metallic conductors of an induction instrument in action. I am afraid you cannot see the small sparks produced as the two electricities combine upon the cutaneous surface, or hear the slight crackling sound, but you observe no muscular contraction, and what I feel is a superficial and evidently cutaneous sensation. I now replace the dry conductors by well-moistened sponges. You see that I have not altered the power of the current, but that there is energetic contraction of the extensor muscles. This is quite involuntary, and is due to the electric irritation of the branches of the motor nerves. It follows from these experiments that we may, at pleasure, arrest electricity in the skin, and that, without puncture or incision, we may make the current traverse the skin, and concentrate its action upon subcutaneous organs.

Muscular electrization may be produced, either, as I have just shown you, by placing the conductors upon the muscle, a procedure termed *direct* or *intra-muscular* electrization; or by exciting only the motor nerve trunk, which is termed *indirect*, or *extra-muscular* electrization, and which we shall consider presently.

For direct excitation of the larger muscles it is convenient to use well-moistened sponges, contained in cylinders of different sizes, or metallic disks, covered with wet leather and having conveniently shaped handles. A useful size of cylinder is one such as this (Fig. 37), having a depth of about 1½ by 1⅛ inches, which allows the sponge to fairly fill it, while in such forms as this—6 inches by 1 inch—when the sponge is inserted the lower three-fourths of the cylinder is empty, and the conduction of the current liable to become imperfect.

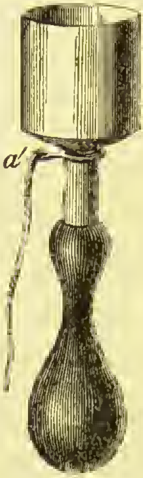

Fig. 37.—Cylindrical Sponge-holder.

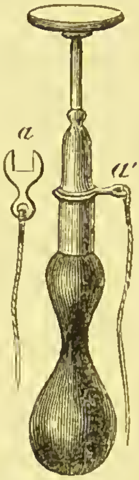

Fig. 38.—Metallic Disk, covered with Wash-leather.

The disk rheophore (Fig. 38), a metallic button covered with wash-leather, is extremely useful; it has the advantage over the sponge of allowing firm pressure to be made without the inconvenience of water being squeezed out, while by using its edge it may be made to answer in the majority of cases for a pointed conductor, which is fitted chiefly for application to very small muscles, such as the interossei and some of those of the face.

The wire is attached to the conductor by being screwed into the socket (See *a′*, Fig. 38). A conducting cord is very apt to get frayed at the point of juncture, and that the wire which I recommend is not open to this objection is not the least of its advantages. In direct electrization the rheophores should be firmly pressed down upon all points of the surface of the muscle, that all its fasciculi may be equally electrized. With the Faradaic current it is convenient to apply the rheophores, held in the same hand (Fig. 39) for from twenty

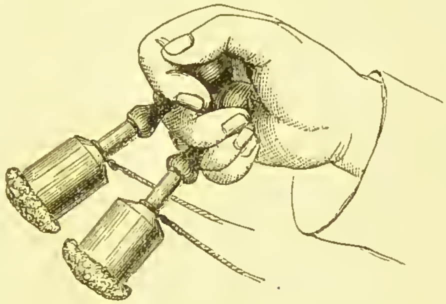

FIG. 39.—Method of holding Sponge-holders with Sponges inserted.

to thirty seconds, to every part of the surface of the muscle, or group of muscles, promenading them as nearly as may be in lines from the origin to the insertion of the muscles. If the rheophores are not held in the same hand care should be taken to keep them near to one another, for the tension or penetrating power of Faradism is so great, that without this precaution there will be liability to excite reflex action. With the interrupted Voltaic current this liability does not exist, and a better plan when using it is to hold the sponge from the positive pole stationary, near to the origin of the muscles, and to stroke or paint as it were the entire muscular surface with the sponge from the negative pole, gliding it in lines from the position of the positive. In using the constant Voltaic current both sponges must be held quite immovable, and so applied it differs altogether in its effects from the very same strength of current interrupted by moving the conductors. I will demonstrate these different applications upon the extensors of my left wrist and fingers —Faradism—Voltaism—Constant Current.

Indirect, or extra-muscular electrization, next claims our attention. You will recollect that it is produced by acting upon the special nerve trunk and its branches, instead of by placing the rheophores upon the muscle itself. We may thus call a motor nerve into action without affecting the cutaneous nerves, and with a minimum of power of current, and necessarily a minimum of sensation which hardly ever need amount to actual pain. This method is preferable, therefore, in cases where we desire to produce muscular contraction and as little sensation as may be, and again when the sedative influence of the constant Voltaic current is required to be localized in any special nerve. In its application it is convenient to place a good-sized sponge connected with one pole upon an indifferent part of the body, such as the sternum, and to apply a pointed conductor from the second pole directly over the course of the nerve it is desired to act upon. Speaking generally, these motor points, as they are called, may be selected by reference to a good anatomical plate, but only approximately, for we know that it is common to find variations in the course of the nerves and in the mode of their distribution among the muscles, and this being so, it is well, when we propose to act upon a motor or mixed nerve (which is not paralyzed), to make sure that we are localizing the current in it by producing for a moment the contraction of its muscles and then marking the spot by touching it with a pencil of nitrate of silver. This, of course, is only necessary where, in our subsequent electrization, we do not wish muscular contraction.

I will demonstrate indirect electrization by Faradizing the median nerve in my left forearm above the wrist, and before it passes beneath the annular ligament of the carpus. It lies a little below the surface, between the tendons of the flexor carpi radialis and palmaris longus. You observe that its muscles powerfully contract and oppose the thumb to the other fingers, at the same time abducting it. There occurs also a slight flexure of the first phalanges of the index and middle finger. Professor Ziemssen, in his work on Medical Electricity, has published some extremely accurate plates of the motor points of the body, and I have grouped together the more important of them in a chart or map for convenient reference.*

Fig. 40 exhibits a convenient method of studying indirect electrization. You observe the back of the left hip and thigh. The black lines and spots are "*Motor Points.*" The skin is removed from the right limb and the muscles are exposed. The nerves are seen in the full-length figure (Fig 41).

We will next consider cutaneous electrization. I have already shown you that when the skin and the conductors are both quite dry, a Faradaic current of moderate power (and practically this form of electricity is always employed in cutaneous electrization) does not penetrate the skin, but is localized upon its surface. There are three methods of applying cutaneous Faradization—the method that we employed—that of "*Metallic Conductors;*" the "*Electric Hand,*" as it is called, in which the operator, having applied one conductor to some little sensitive part of the

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* Published by J. & A. Churchill.

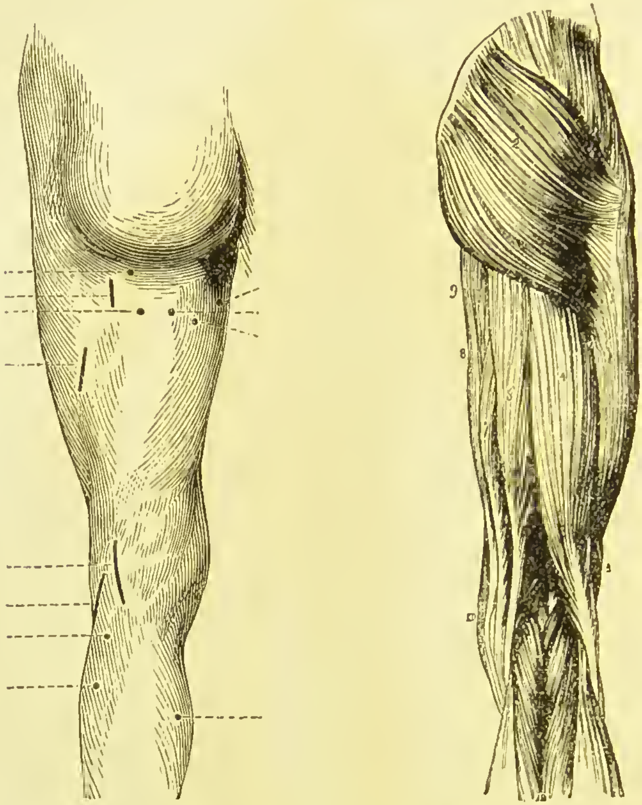

Fig. 40.—To illustrate Indirect Electrization.

patient's body, holds the second in his left, and passes the back of his right hand over the points he wishes

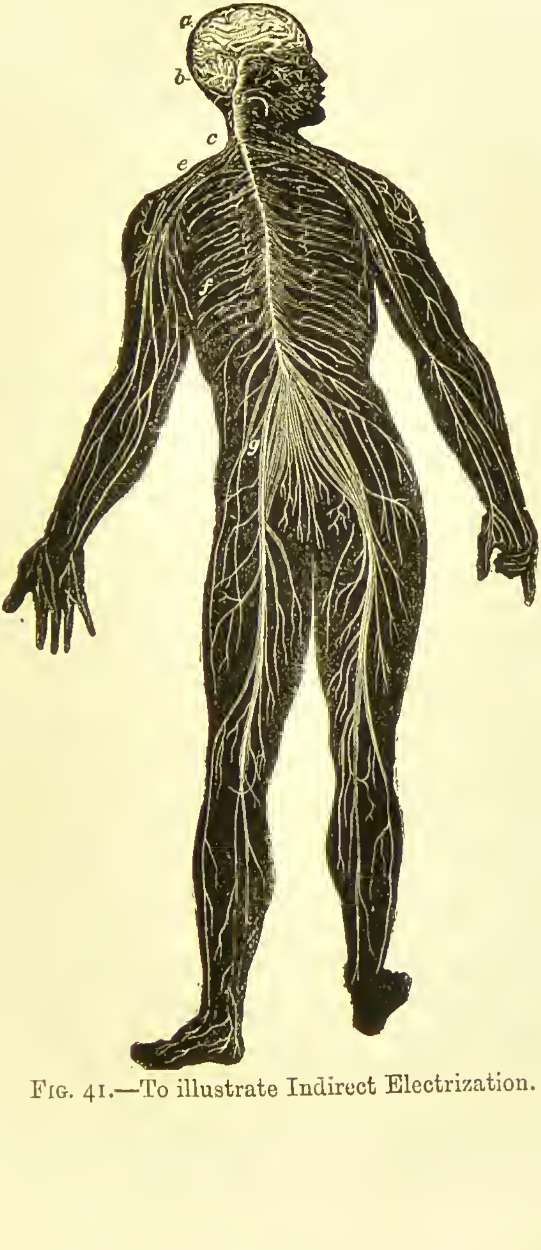

FIG. 41.—To illustrate Indirect Electrization.

to excite, these points of the patient's skin and the back of his hand being dry, and sprinkled with absorbent powder ; and the " *Wire Brush,*" a brush of metallic wire, which replaces one of the conductors, and which is moved over the skin. With a strong Faradaic current this wire brush becomes the most powerful of all the excitants of the skin which do not disorganize its structure ; in fact, it was proposed by some scientific parliamentary philanthropist as a substitute for flogging in the Navy, and I have no doubt that more intense pain may be produced by it than by any application of the cat, however well laid on! The methods of electrizing internal organs need not detain us long. The rectum and muscles of the anus may be electrized by introducing into the rectum the rectal rheophore, a metallic stem insulated by gum elastic, and moving it over the internal surface. A well-moistened sponge connected with the other pole may be applied to the abdominal muscles or to the neighbourhood of the anus. The rectum must be first freed from fæcal matter. The bladder is most readily electrized by the introduction into the rectum of the rectal rheophore, and into the bladder—previously emptied—of a curved metallic sound, insulated by an elastic catheter, to within an inch of its vesical extremity. This sound must be brought into contact successively with all points of the neck of the bladder. The uterus, by the introduction of the rectal rheophore, connected with one pole, to the os uteri, and by the application of two sponges from the other pole, one to the abdominal parietes, the other to the lumbar region. The larynx, externally by one sponge to the nape of the neck, and the second to the exterior of the larynx; or, internally, a sponge to the neck as before, and the introduction, by the aid of the laryngoscope, of a small bit of sponge at the end of a curved metallic stem, insulated by a gum-elastic catheter, the current not being allowed to pass until it is seen by the larnygeal mirror that the sponge is in the desired position.

In electrization of the central organs of the nervous system, the Voltaic current is alone used, and in its application to the brain, the sympathetic nerves, or the organs of the senses, especial circumspection must be employed. As a general rule it should not be had recourse to when central excitement is contra-indicated, and in *all cases* the minimum dose should be commenced with, and the application discontinued upon the occurrence of giddiness, nausea, or cerebral symptoms. With these precautions, the brain may be electrized by well-moistened sponges applied to each mastoid process, to each temple, or to the frontal and occipital protuberances. The sponges must be held immovable. To galvanize the superior cervical ganglion of the sympathetic, one electrode of small size must be deeply pressed into the auriculo-maxillary fossa, and the other with a good-sized sponge applied over the sixth or seventh cervical vertebra, or to the manubrium sterni, close to the border of the sterno-mastoid. The spinal cord may be electrized by keeping one sponge, usually the positive, stationary, and moving the other up and down by the sides of the vertebræ, or one pole may be applied to the spine and the other held to a nerve or muscle. The retina by a moistened conductor to the closed eye, and the second to the temple or to the mastoid process of the same side. The auditory nerve by one conductor tipped with sponge and inserted to the bottom of the meatus, the second being held in the hand of the opposite side; or the meatus may be filled with tepid water, and a metallic wire traversing the axis of a vulcanite tube may be immersed in the water, the second conductor being a well-moistened sponge to the nape of the neck. Direct application to the ocular muscles, or to the conjunctiva, is usually inadmissible, but one pole may be placed over the facial nerve below the ear, and the other applied to the closed eyelid, or the operator may use the forefinger of his right hand, covered by a finger-stall of wet linen as an electrode, passing the current through his own body by holding a moistened sponge from one pole in his left hand, the conductor from the second pole being similarly held in one of the hands of the patient. This application is not only convenient, but it is calculated to allay the fears of a sensitive patient; or a pointed conductor, covered with wet leather, may be connected with one pole, and its point held immovable and firmly pressed down upon the orbital margin, as near as possible to the position of the muscle it is desired to excite, while the patient touches at intervals the sponge from the second pole held by its insulating handle in the operator's disengaged hand.

And now there is one *final* application to which I would ask your attention.

For some years I have conducted observations and experiments, at our hospital and elsewhere, with the object of ascertaining whether an apparatus might not be constructed which would generate a current of

Voltaic electricity sufficiently powerful, *when properly applied,* to penetrate the skin, and yet of such low tension that it might be applied for many hours together without producing inconvenience. The answer having been a most satisfactory affirmative, I show you the apparatus.

It consists of an ebonite cell, or cells, containing the Voltaic elements, immersed in their exciting fluids. The top of each cell unscrews, to admit of recharging when exhausted. The connecting cords may be attached to the different appliances I now show you. It is claimed for this complete apparatus, taken together and applied as directed, that it practically constitutes an entirely new departure in medical electricity, and that there is now placed at the service of the profession an adequate means of testing upon a large scale the effects of prolonged electrization upon nutrition. When we know that trees through whose roots a galvanic current has been maintained, have grown much more rapidly than similar trees planted at the same time, and that newly born animals have been galvanized daily, with the result that at the end of six weeks all those that had been galvanized weighed more and had grown larger than those that had not, it would seem that the treatment advocated is full of promise.

Next week we will consider electricity in the treatment of disease.

DEMONSTRATION III.

In this concluding Demonstration of our present course, I propose to consider electricity as a *remedy* for the cure and alleviation of disease—the doses in which it should be administered, the way to graduate those doses (*we have already studied how to give them*), and the diseases usually benefited by them. At the end of the course, I shall give you twelve printed questions,* which I shall be glad if those of you who are studying for the certificate of our School will kindly answer *fully* in writing, and return to me as soon as possible. It will also give me pleasure to receive, and consider, answers from those of you who are merely attending these lectures.

And now with regard to dosage. Unfortunately,

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* The questions were as follows:—

1. What *varieties* of electricity are used in medical practice, and, in using any one of them, what is the first rule to be observed?

2. You are asked by a doctor, experienced in electricity, and who believes you to be experienced, to "*Faradize*" an arm completely paralyzed from the shoulder to the fingers. State exactly, and in *full detail*, what you would do.

3. The same doctor asks you to apply the Voltaic current for severe "*sciatica.*" State exactly what you would do.

4. Another doctor, knowing little of electricity, but believing you experienced, asks you to "*Galvanize*" a child

we cannot measure out electricity in tablespoonfuls: and I wish, indeed, we could! The dose of electricity is made up of two factors—(1) Its strength; (2) The *time* during which it is applied to the patients. *Can we determine its strength?* It is, as you know, a FORCE, and, as with other *forces,* it has its standard of measurement. We graduate *time* into hours, minutes, and seconds, and our graduated measure is a clock or watch. We graduate electricity into what are called *amperes;* and our graduated measure is a galvanometer. The galvanometer is founded on the principle that a magnetic compass needle has a tendency to place itself at right angles to a current of electricity—as I have shown you several times during these Demonstrations; but galvanometers vary, *and the degree to which the needle is deflected is not proportionate to the electric power.* The only practically

about two years old, and who is paralyzed in one leg. He leaves the form of "Galvanism" and the method generally to you. State exactly what you would do.

5. State how you would give an electric bath to an adult.

6. How would you "Galvanize" the brain, and what variety of electricity would you use?

7. Can you administer electricity in "*doses,*" and if so, how would you measure the dose? Give an example.

8. What are the precautions to be observed in all medical applications of electricity?

9. Describe how you would *not* use electricity.

10. What are the diseases generally benefited by electricity?

11. You are "*Galvanizing*" a patient, and he suddenly tells you he ceases to feel *anything.* What would you do? Explain fully.

12. Give a short account of ALL methods of using each variety of medical electricity.

useful galvanometer for you is, therefore, one in which the dial-face is divided, not into equal degrees, but into divisions of an ampere, called *milli-amperes.* Don't trouble about this high-sounding name, but impress it upon your memory: and see that the galvanometer you use is divided from 1 to 300 milli-amperes. These divisions are arrived at by taking a compass needle *and noting the deflections given by it with currents of known strength,* and by marking these upon the dial-face.

This is done by the galvanometer-maker, as is your watch by the watchmaker. You look at your watch, and find minutes and seconds. You look at your galvanometer, and find amperes and milli-amperes.

You will find* (as stated by Dr. De Watteville) that while a current of 30 milli-amperes deflects the needle to about 45 degrees, it takes a current of 150 milli-amperes to deflect it to 70 degrees, and so on. If requested by a physician, then, to administer so many milli-amperes, you *employ the exact number of cells that will cause the needle to cover the number of milli-amperes required;* and you are guided ENTIRELY, not by cells or batteries, but by the position of the needle. It is hardly necessary for me to remind you that it is only the Voltaic current, *and not the Faradaic,* that can be measured by a galvanometer.

So much for measuring the current which leaves the battery! So far, the question is simple; and the word "*galvanometer*" will probably become as complete a refuge for certain destitute medical electricians as has long since become the word "*hysteria*" for certain

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* See Fig. 41A, also p. 29 of Dr. De Watteville's "Medical Electricity" (London: Lewis, 1884).

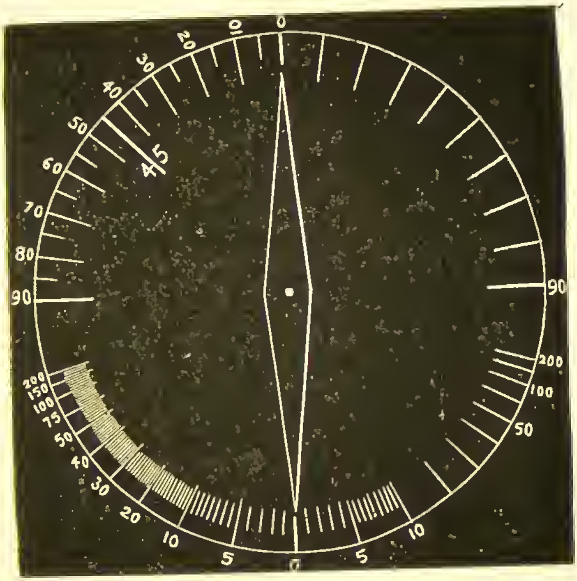

FIG. 41A.—A Galvanometer divided into Milli-amperes.

The upper scale is divided into equal degrees; the lower into Milli-amperes. The statement in the text is easily verified by laying a pencil or penholder across the Figure.

[*To face p.* 76.

similar physicians. But, firstly, galvanometers, like clocks and watches, are liable to get out of order; and, secondly, the measure of the strength of current is a *very* minor portion of your dose of electricity. If you give a tablespoonful of any medicine, it is swallowed; and you, at any rate, have done with it. That is the *complete* dose. But with electricity, if you give so many milli-amperes, it is but the *very beginning. The dose really consists of the length of time during which you apply it.* A certain strength administered for five minutes is totally different from the *same* strength administered for twenty minutes; and not only so, but, as I have shown you—tested on yourselves—30 milli-amperes will produce a certain effect upon one, and 40, or more, will be required to produce the same effeet upon another, and perhaps 20 will suffice for the third.

If you are to practise as electricians, you must, of course, be prepared to measure out "*milli-amperes*" if asked to do so; and the responsibility will then rest upon the prescriber, not upon you.

When not otherwise directed, I strongly advise you to graduate your dose of *any variety* of medical electricity by a consideration only of

1. *The power as tested upon yourself;*
2. *Its effect upon your patient.*

You will always employ the *lowest* power which will bring about the result you desire: and you will take care not to prolong your application for too great a length of time.

It may perhaps not be out of place to remind you, in concluding this part of our subject, that certain precautions are necessary to be observed. You must keep constantly before your attention that you are prescribing or administering an exceedingly powerful remedy, and with all new patients you should commence with a minimum dose, watch its effect, and if you need to increase it, do so gradually; *e.g.*, muscular contraction being sought, you must use the power just sufficient to produce it, and *no more*, and so on with other applications. And it is especially necessary to use care in applying the Voltaic current to the face, neck, or any part of the head. Sudden applications and sudden cessations should especially be guarded against. The cessation shock can, of course, only occur in cases where the conductors having been held immovable, and the current gradually increased, one or both of them has been abruptly, and it may be inadvertently, removed; and I have known a patient so frightened by such a cessation shock as to decline further treatment. The negative pole of a Voltaic battery will, if frequently applied to the same spot, soon cause a sore, and to avoid this, the point of application should be slightly varied occasionally; and let me impress upon you again the importance of always testing electricity upon yourselves before applying it to a patient. Use as many galvanometers, or so-called "instruments of precision," as you like, but use in addition the back of your left hand as a convenient approximate test for the Voltaic, and your thumb muscles for the Faradaic, current, except when about to apply electricity to your patient's head or face, and make it then an invariable rule to first apply to your own face the same strength of current you are about to administer to your patient's. If you authorize your patient to have treatment carried out at home, impress this rule upon whosoever electrizes him. Under such circumstances it is especially imperative, for there is great belief, even with educated persons who ought to know better, that the benefit derived from electrization is in exact proportion to the pain given by it, and a little personal experience is a very wholesome corrective to such a notion. Graduate your dose, then, by the number of cells employed checked by testing its effect, and do this upon each application, for there is no certain means of securing that the strength of either a Voltaic or a Faradaic current shall not have varied from day to day.

And now let us shortly consider our work.

Regarded as a remedy, medical electricity is of great value in a wide margin of disease, and recent improvements in electrical apparatus enable treatment to be conducted with a degree of precision and success utterly impossible with old and imperfect instruments. *But it is solely by its careful and skilful administration* that electricity will do good and not harm. We all know the tendency of "new brooms," and I have no hesitation in saying that in the great majority of cases the application has been both too long and too strong. Electricity will either stimulate or soothe, according to its variety and mode of administration, but we almost always require—not its power of giving "shocks," but its very remarkable restorative and refreshing effects. It will frequently restore a measure of power to the paralyzed, and relieve—sometimes as if by enchantment—severe and long-standing pain. It should always be employed when the organism from any cause has become enfeebled, as in the general weakness of old age, in fatigue diseases, in loss of functional power, in certain uterine irregularities, in conditions of debility following acute diseases, in cases of general prostration from overwork or anxiety, in all functional diseases of the throat, in sleeplessness, in asthma, in certain cases of melancholia, in cases of gout and rheumatism, and in all cases of neuralgia (such as sciatica) or other painful conditions.

Surgery also owes much to it, for it will dissolve or slowly cause the absorption of tumours, in appropriate cases replacing the use of the knife; while there is also evidence that there is a less frequent return of cancerous growths removed by its agency than by the ordinary operative procedures. In addition to its remedial use, electricity often enables the physician to tell with certainty the cause and seat of the disease, and so places him in the best position to attempt its cure by other means.

So much for the general effects of electricity. All the structures of the body respond to its application—the muscles and motor nerves, as we have seen, by contraction; the nerves of common sensation by a burning or pricking; and, of the nerves of special sense, the retina by a flash of light, the auditory nerve by a sound, the olfactory nerve by a peculiar smell, and the gustatory by a metallic taste, differing at the two poles. The action of the Voltaic current upon the brain is exceedingly powerful, and the greatest care must be exercised when it is applied to any part of the head or face. Not more than two or three cells should be commenced with. Its effect should be noted, and any increase should be made gradually. With a very moderate current giddiness is produced, and upon the sudden application of a sufficiently powerful one the patient falls down as if struck by a blow.

The Voltaic current enjoys a remarkable restorative power, for it has been found that its prolonged action upon a nerve immediately after death will preserve its irritability for a length of time, and that even in a dead nerve the lost irritability may be again established. It is especially useful in the treatment of what are called " fatigue diseases," diseases characterized by an intense feeling of fatigue upon any attempt being made to execute certain muscular movements. This tired feeling is at once removed by the application of the Voltaic current, either to the muscles affected or to their nerves, and this result may perhaps be explained by an increase in the susceptibility of the muscles to the stimulus of the will. Be this as it may, such an application is often most comforting, and it is not unusual for the patient to experience immediate and most grateful relief, and to beg for its repetition.

In the treatment of *neuralgia* by the constant current the electrodes should be so applied as to include between them the part or nerve affected—the number of cells the highest number that can be borne without pain, *i.e.*, the current to be distinctly but not painfully felt, both electrodes being immovable. Time five to ten minutes. Frequency as often as the attacks of pain recur. I am satisfied that in severe cases this rule of application is essential—that the influence of the current shall be maintained as much as may be in the irritable nerve during the intervals of pain. In one case under my care the patient was galvanized with benefit twenty-seven times in the twenty-four hours; but in milder cases one or two applications daily will generally suffice. A weak current from two or three cells—the electrodes being applied to each temple for one or two minutes—will sometimes dissipate a severe headache. This soothing influence of the current is often useful in allaying *Spasm,* as, for example, in spasmodic wry neck. The current should be localized in the irritable muscles; and it is generally advisable to energetically Faradize their antagonists and to conjoin with the electrical treatment massage and appropriate gymnastic exercises, alternating with periods of perfect rest.

There are very few, I think I may almost say not one, of the many disorders classed under the heading of paralysis, in which at some time or other of their progress some form of electrization is not essential to their most successful treatment. Where powerless to cure it will not unfrequently relieve the most distressing symptoms. Cases of functional paralysis from slight pressure are not uncommon, when power may usually be restored by a few Faradizations; but in severe paralysis progress must of necessity be slow. Such cases, regarded electrically, may be most conveniently considered under the two divisions of paralysis —where the muscles are "wasted," and paralysis where they are "normal." In the great majority of cases where the muscles are wasted, there will be found abolition or modification of the normal electrical reaction of nerve and muscle; but whether this is so or not, in all cases of loss of power, in which any muscular wasting is visible, the localization of electricity in the wasting muscles is *imperative,* and in some varieties it is the only treatment which will arrest the disease. It is in these latter cases that its early administration is called for, before the degeneration and disappearance of the muscular tissue, and its early and judicious use will not seldom save the sufferer from being left for life with a powerless, or withered and deformed limb. As an illustration, let us review the progress of a case of essential infantile paralysis, the most common of the paralyses of children—that form in which premonitory symptoms are often absent, or but slight. Very shortly after its onset, usually within a few days, the limb is found to be colder than its fellow, and its muscles to be rapidly wasting; the final result, if untreated, being the entire disappearance of some of them and the production of deformity. *In fact, the larger number of cases of clubfoot and analogous distortions are brought about by neglected infantile paralysis, and there is no doubt that by judicious treatment, of which early electrization is the foundation, the majority of them might have been prevented.* The leading orthopædic surgeons are fully alive to this fact, but they *are powerless, as they are rarely consulted until all the mischief has resulted.* The early recognition and appropriate treatment of these cases must continue in the hands of the family practitioner, and he must decide whether or not they are to continue, as at present is unfortunately too commonly the case, without any serious attempts at restorative treatment until commencing deformity compels attention to them. As soon as the medical attendant is summoned—and this is frequently only because the parents have noticed that the child is lame—he should carefully examine the muscles electrically, and unless there are head symptoms present, and this is very seldom, he should electrize each muscle daily with that current to which it responds and of a strength just sufficient to produce muscular contraction. If the powerless muscles have preserved their Farado-contractility it may be confidently predicted that they will rapidly recover; but it will almost invariably be found that while Farado-contractility is diminished or abolished, there is increased response to the interrupted Voltaic current. They should be treated then with this current alone. Careful and regulated *massage* should also be employed, and it is of great importance that in the intervals of treatment the temperature of the affected muscles should be maintained at as high a degree as possible. If the leg is affected, a stocking of pure spun silk should be constantly worn, day and night, in addition to the ordinary clothing; if the arm, a silken sleeve.

In paralysis without wasting—of which one-sided paralysis or hemiplegia may be taken as a type—the propriety of electrization, and especially the proper moment for its application, requires careful consideration. In both brain and spinal cord disease muscular electrization is not advisable until some time after the attack, or until the muscles exhibit signs of impairment of nutrition from disuse. As long as there is rigidity any stimulant application of electricity is not likely to do good, and may do harm; but in older cases—cases of from six to eighteen months' duration—the immediate benefit to be derived from localized electrization is often remarkable, especially in those cases where, after a partial return of voluntary movement, the patient suddenly stops short, and for weeks or months makes no progress. As the sequel of electrization, the patient able to use the arm slightly, but not to feed himself, may regain this power, to his infinite comfort, and the patient, able with difficulty to drag himself along by crutches, is enabled to walk by the aid of a stick. Some improvement is usually soon obtained, and it is progressive for, perhaps, two or three months, after which continued electrization fails to increase it; but at a subsequent period—six weeks afterwards—a renewed electrization may give rise to a new improvement; but be this as it may, whenever in these old-standing cases we see signs of impaired nutrition, it is wise to occasionally stimulate the muscles by Faradism. We should endeavour—in the words of the Nestor of modern medicine, Sir Thomas Watson—"to preserve the muscular part of the locomotive apparatus in a state of health and readiness, until peradventure that part of the brain from which volition proceeds having recovered its functions, or the road by which its messages travel having been repaired, the influence of the will shall again reach and reanimate the palsied limbs."

It is remarkable that electricity should have been so little used in this country in the diseases of women. On the Continent it has been largely employed. There are certain cases in which electricity would seem to be *facile princeps* THE remedy. It has been said to be the only true emmenagogue that we possess; and a case has been reported of the re-establishment of the catamenia and the cessation of sympathetic epileptic attacks that had persisted for three years, brought about by the constant Voltaic current; and it is my firm belief that if a Faradaic instrument were at hand, and properly used, there would never be another death from *post-partum* hæmorrhage. The Faradaic current, thoroughly localized in the womb, will always produce its contraction not only while life persists, but even for a limited time after death.

The stimulant effects of electricity are occasionally beneficial in the treatment of paralysis of the nerves of special sense, especially of the optic and auditory nerves, while its use has been advocated in a multitude of diseases to which I shall not further refer, than by saying that a clear comprehension of the principles of electro-therapeutics will prevent the occurrence of difficulty in any special application of them.

In my last Demonstration I alluded to the development of a novel method of applying electricity—*that by currents of low power for lengthened periods,* a method originated by myself. This mode promises to bring within the range of curative treatment, a class of cases of disease, more especially certain forms of "nerve prostration," and analogous conditions, and some varieties of epilepsy, previously little amenable to medicine.

I am unable to say more at present than that I have confidence this promise will be fulfilled.

In conclusion:—Are you as Nurses, Electricians, and Masseuses entering upon a good and useful work —a work which will not only return you that "hire" of which we are told in Holy Writ the labourer is always worthy, but that far better recompense—the enduring gratitude of your patient?

I say emphatically, Yes.

And is there any greater pleasure than is experienced when having earned such thanks, they are freely and cordially given?

If you qualify yourselves, by not only attending our Lectures, but by what is of infinitely greater importance, diligent and hard work in our Hospital Electrical and Out-Patient Rooms, you will become expert in the many details and manipulations of what may, not inaptly, be called our "*Advanced School of Electricity and Massage*," and your "Certificate of Qualification" will be regarded by the public as a guarantee of your possessing the highest available skill in these Sister Arts; and by the Medical Profession as a testimony that a new class has arisen, as superior to the so-called electrician and shampooer as is the hospital-trained nurse of to-day to the "Sarah Gamp" of the bad old time! *

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* Whatever may have once been the case, the good workman is now recognized, not by his using few, but by his using many tools. We know, of course, that "*of drinking of physic there is no end;*" and, in these high-pressure times, it may be said of it that in skilful hands, it often works marvels!

We, as Specialists, have to do with a special class of diseases —those of the Nervous System; and when our patients come to us, they have generally drank medicine *ad nauseam*, and seek other remedies.

Of Electricity I will say no more; but she has two handmaidens—Massage and Medical Gymnastics—both of great importance.

Massage has been defined by my colleague, Dr. Stretch Dowse, to consist of "Modes of manipulation, of every possible variety, of Finger, Hand, Knuckle, Wrist, and even Arm movements. These vary considerably in their nature, and differ entirely from ordinary Shampooing. They may be summarized as a series of Rubbings, Pinchings, Strokings, Slappings, Shakings, and Kneadings. They are classified by our Continental friends as '*Effleurage*,' '*Massage à Friction*,' '*Petrissage*,' and '*Tapotement*.'"

In various diseases of the Nervous System the daily practice of regulated Gymnastic Exercises is of the very first importance. This is especially so in many forms of paralysis. In these latter cases, when ANY amount of voluntary power has been restored by electricity or otherwise, it is imperative that the patient should be encouraged to *use* the limb or part; and there is often the very greatest difficulty in getting the patient to even try to do this.

If unable to do so, the natural movements of the part should be imitated by what are called "passive movements"—that is, by a nurse grasping and "working" the limb as nearly as possible after Nature. For example, if the muscles which extend or open the hand or fingers are paralyzed, and the hand remains obstinately shut, or if the forearm is rigidly bent at the elbow, the hand and fingers should be opened by the nurse, and the elbow should be straightened at intervals of a few seconds, and this continued for some fifteen minutes, *with due discretion as to the power used.* So on with other paralyzed muscles.

Those who have gained a measure of power, however small, should also call gymnastic apparatus to their aid, upon which they should daily exercise their weakened muscles.

The Imperative Rule is—"*Exercise short of fatigue;*" and this is most important.

Patients, in their anxiety to get well, are so given to overdoing every treatment left to them; *and this is why they should always call in their customary medical attendant to supervise their exercises.*

Patients "rush in where physicians fear to tread!"

With regard to Gymnastic Apparatus, the old system of elastic "extenders," or "bands," should never be used, but a system of graduated weights.

The following figures illustrate useful movements:—

Fig. 42 shows a movement especially applicable to strengthen the arms and chest.

Fig. 43 one for strengthening the muscles of the neck, back, and abdomen.

Fig. 44, a special movement appropriate for curvature of the spine, &c. &c.

Makers of Gymnastic Apparatus are many, and any one of them will be able to supply the special form desired by the medical attendant.

The results of gymnastic treatment, as an *Auxiliary* to other treatment, have been very satisfactory. Gymnastic movements are not applicable to severe forms of paralysis, yet they often contribute much towards complete recovery as soon as some improvement has been caused by other and more powerful remedies. In *Chorea*, or St. Vitus's Dance, and in certain hysterical affections, gymnastic exercises are of *very* great value, and rank among the most effective means which are at the physician's disposal for the alleviation and cure of these diseases.

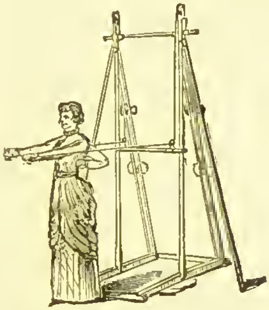

FIG. 42.

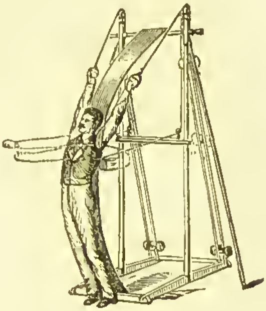

FIG. 43.

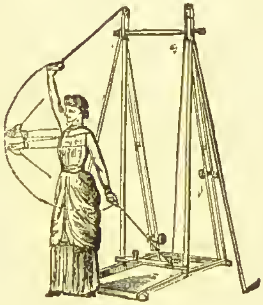

FIG. 44.

The following is an extract from Dr. Sturge's Report of the results of treatment at the National Hospital for the Paralyzed and Epileptic :—

"Some striking cases have occurred, and in all of these the improvement is mainly due to the electrical treatment prescribed.

"A patient, with wasting of some of the muscles of both arms of six months' standing, which incapacitated her from dressing herself or cutting her food, or doing much household work, was discharged at the end of three and a half months, able to feed and dress herself, sew, and perform almost any domestic duty.

"Another woman, with wasting of the muscles of the forearm of several years' standing, and who was similarly incapacitated from almost all use of the hands, went out, after a month's treatment, able to dress and feed herself, and to perform many actions that were before impossible for her.

"A man came to the hospital with wasting of many muscles in various parts of the body, more especially in the left arm, which he was unable to move from the side. He went out able to lift his arm well over his head, and with much increased strength in the limb.

"Another man, in a very similar condition, was also greatly benefited; and whereas on admission he could barely bend the right arm at the elbow, after three months' treatment he was able to use a hammer with the arm."

The following cases occurred in the practice of the West-End Hospital:—

Case I. *Paralysis with loss of speech.*—An engine-driver. Was wheeled into the consulting-room, unable to stand or speak. After six months' treatment his speech has entirely returned, and he walks well with a stick, there remaining only slight weakness of the right side.

Case II. *Paralysis.*—A woman, twenty-seven years old. Marked paralysis of the right side of the face. She was unable to close the eye, and the angle of the mouth was much distorted. After three months' electrical treatment—the patient attending three times a week—she was discharged, able to close the eye, and with very little remaining of the distortion of the mouth.

Case III. *Paralysis* (*Functional*).—A carpenter, twenty-seven years old, had suffered for six weeks prior to attendance from inability to use his plane, having no power to push it. Three applications of electricity completely restored the weakened muscles.

Diseases of the nervous system stand in striking contrast to the *acute* diseases treated in general hospitals. These latter run their course commonly in a few days, or, at most, in a few weeks, ending then in recovery or in death.

Diseases of the nervous system, on the contrary, are, as a rule, of long duration: in many instances symptomatic of organic mischief, of hereditary disease, or of congenital deficiency. They are essentially *chronic* diseases, and they require, so to say, chronic treatment—treatment not usually productive of immediately brilliant results, but treatment which, if earnestly, patiently, and perseveringly continued, will not seldom result in progressive amelioration, and sometimes, even in cases not long since regarded as incurable, in complete recovery.

H. T.

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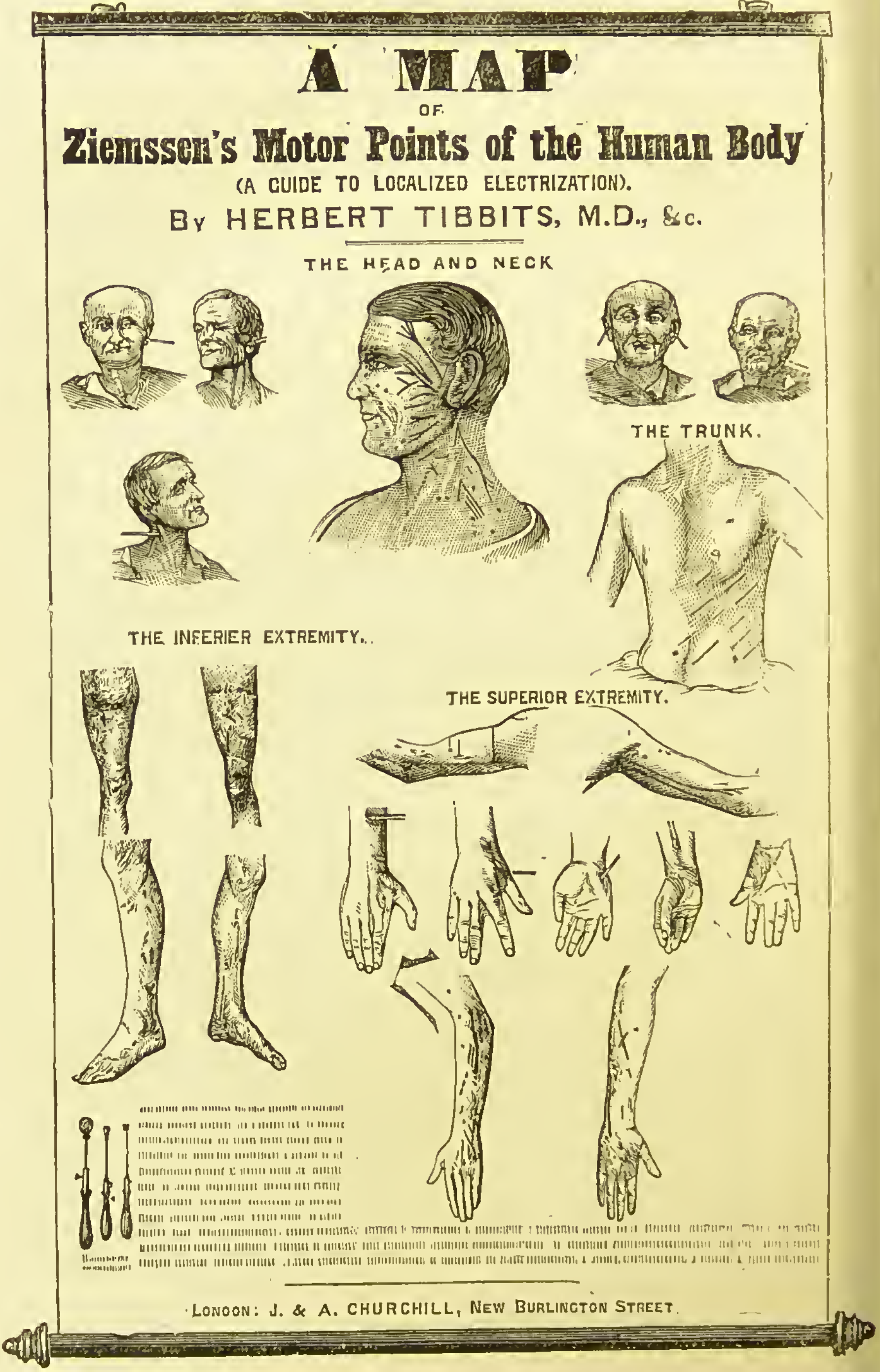

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